CATECHISM

ON

CHEMISTRY,

ADAPTED TO THE COURSE OF LECTURES DELIVERED

IN THE

UNIVERSITY OF PENNSYLVANIA.

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PREFACE.

Such is the importance to which chemistry has attained, in its practical adaptation to all avocations of life, that ignorance of its general principles, among the members of ordinary occupations, has become almost inexcusable, and much less so with the student of any branch of science.

The neglect which it has heretofore received from those preparing themselves for the practice of medicine, is very great; and it is difficult to conceive how an individual, whose duty consists in ministering to the ever varying diseases of the human frame, can possibly call himself a proficient in the healing art, who remains ignorant, or imperfectly versed in a science, the principles of which enter so largely into a proper knowledge of the *modus operandi* of his profession.

It is not the mere faculty of retaining in the memory what is said in public lectures, that changes a student into the useful and practical physician. He must make close investigations for himself—he must become thoroughly acquainted with the principles of every branch of his science—he must learn the constituents of every potion he administers; the separate and combined action of each ingredient on the system—before he can be properly prepared to fulfil the high and responsible station which he assumes, with dignity and honour to himself, and with advantage to society. By these means only can he ever

expect to occupy a permanent and elevated station among the members of his profession.

This little contribution is offered to the student of medicine with all diffidence; with the contemplation that it may form what is so much wanted in chemistry—a stepping stone to the more enlarged views and doctrines embraced in our standard works on this science. The better to subserve this purpose, as well as to enable the author to give it a degree of condensation which could not otherwise be attained, the form of a catechism has been adopted throughout the volume. From this cause, the language may occasionally appear rather uncouth; but this, at all times, is preferable to verbosity. The compendium of lectures by Dr. Hare has been assumed as its basis, and the order and improved nomenclature of that distinguished chemist adhered to as nearly as possible.

The author makes no pretensions to originality; he asks only for the credit of giving a ery condensed and correct compilation from the works of our most approved writers. And with the hope that it may be useful in its sphere, he begs leave to offer it to the students of medicine, in our different schools, to whom it is most respectfully inscribed.

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CHEMISTRY.

Question. What is chemistry defined to be?

Answer. It is that science which treats of the phenomena and operations of nature, which arise from reaction between the particles of inorganic matter.

Q. How is the distinction between Chemistry and the sciences of Natural Philosophy and Physiology defined?

A. Natural Philosophy, in its limited acceptation, is that science which treats of those phenomena that arise from reaction between masses, or between a mass and particles. Physiology treats of those operations that arise from reaction between the particles of organic matter; while the phenomena which arise from reaction between the particles of inorganic matter are embraced in the science of Chemistry.

Q. How is chemical reaction divided?

A. Into attractive reaction, or attraction; and repulsive reaction, or repulsion.

Q. Does attractive and repulsive reaction exist in the same kind of matter?

A. No. Matter is of two kinds; one, from possessing weight, is called ponderable; the other, not being detected as possessing weight, is called imponderable. In the former kind, attraction exists; in the latter, repulsion.

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REPULSION.

Q. Can you enumerate the imponderable bodies?

A. Electricity, magnetism, caloric, light.

ELECTRICITY.

Q. What is electricity defined to be?

A. The unknown cause of the attractive power which certain substances acquire by friction.

Q. How early was this discovery made?

A. Six hundred years before Christ, when it attracted the attention of Thales.

Q, What is the term electricity derived from?

A. The Greek word (electron) signifying amber, the substance in which this power was first noticed.

Q. When was any additional discovery made?

A. In the seventeenth century, Otho Guericke observed that light and sound might be the effect of electrical excitement.

Q. How is electricity excited?

A. By mechanical and chemical means. Mechanical electricity is produced by subjecting certain substances to friction and pressure; galvanism is electricity evolved by chemical agency. Substances excited by mechanical means are called electrics.

Q. What substances are electrics?

A. Amber, glass, resins, &c.

Q. Can the electric virtue pass from one part of an electric which is excited, to another?

A. It cannot without extraneous aid; hence electrics are nonconductors.

Q. What substances are conductors of electricity?

A. Metals, charcoal, flax or hemp, and water. The metals are the only perfect conductors, though they are not equally good. Next to metals charcoal is the best.

Q. Are conductors electrics?

A. No. Because they convey off the electric virtue. Electrics are nonconductors, and conductors are nonelectrics. Sulphur, resin, glass, silk and wool are nonconductors.

Q. Can a conductor be excited?

A. It can, provided it be supported upon a nonconductor; that is, insulated.

Q. What was the theory of Du Faye?

A. That there were two electrical fluids, one kind excited by rubbing glass, called vitreous, the other excited by rubbing resin, called resinous electricity. When either kind of excitement was communicated to light bodies, they were made to separate from each other, but the bodies excited by means of glass were attracted by such as were excited by means of resin.

Q. What did Franklin ascertain to happen when either kind of electricity is communicated to a body by friction?

A. That the opposite kind was created in the mass by means of which that friction is affected, provided it be insulated. For instance, when a glass tube is rubbed by an insulated cushion, the former will be vitreously excited, the latter resinously; but if a stick of resin be substituted for the glass, the latter will be resinously excited, and the cushion vitreously.

Q. What was Franklin's theory of electricity?

A. That there is but one electric fluid—to different states of which the names of vitreous and resinous electricity had been applied erroneously. The latter he called negative, the former positive electricity.

Q. How did he account for the fact that when either kind of electricity is communicated to a body by friction, the oppo-

site kind will be excited in the rubber, provided both be insulated?

A. That some bodies, by friction, acquire additional power to hold the electric fluid, and hence draw it from the conducting body rubbing them; others have their capacity for this fluid diminished by the same means, and hence give it out to the rubber. Glass, for instance, becomes redundantly, and resin deficiently excited by friction.

Q. When glass is rubbed by the hand what happens?

A. It takes electricity from the hand and the person to whom it belongs.

Q. Suppose the person be insulated?

A. He would be negatively electrified, that is, the glass would be positively electrified at his expense, as the communication with the earth is cut off by insulation, from whence the electricity was derived.

Q. Suppose the glass be in contact with another body?

A. The body will be excited vitreously or positively.

Q. Suppose a stick of resin be substituted for the glass?

A. Vitreous electricity will be excited in the person, and resinous in the body touching the resin.

Q. How did Franklin identify lightning with electricity?

A. By drawing this fluid from the clouds by means of a kite.

Q. What is necessary to form an electrical machine?

A. An electric situated so as to be subjected to friction, one or more collectors attached to a prime conductor, properly insulated, and one or more cushions for rubbing the electric.

Q. What happens when the two conductors of a machine in operation are made to communicate by means of a perfect conductor?

A. An electric circuit is formed. In this case all excitement ceases; proving that the redundancy in the positive is equal to the deficiency in the negative conductor.

Q. What are the poles defined to be?

A. Those parts of the circuit through which sparks pass; or that point of an electric, galvanic, or voltaic circuit, at which ignition, light, chemical decomposition, or sensation, are perceived.

Q. What happens if any perfect conductor be in connection with either pole?

A. It assumes the same electrical state as the pole, and transfers the polar influence to the other end of the conducting rod or wire.

Q. What happens when either side of a pane of glass is charged?

A. The other side will acquire a charge of the opposite nature. That is, a stream will be given off as the opposite side is vitreously excited.

Q. When was the Leyden phial invented?

A. In the year 1746, by Cuneus and Mushenbroeck.

Q. Does the electricity of the Leyden jar reside in the coating?

A. No. By removing the coating it will be found in the glass.

Q. What is the use of the coating?

A. In order that every point of the glass on both sides may be brought into communication at the same moment.

Q. What is the electrical battery?

A. A number of Leyden jars with a communication between their interior coatings.

Q. What is meant by the term of electricity by induction?

A. It is the electric state of a body, which is induced by contiguity with an electrified body without contact—or where one surface being in contact with an excited conductor, a tendency is induced in the electricity, on the other side of the electric, to leave it.

Q. What happens when one surface of a pane of glass is in contact with the negative pole in a state of insulation?

A. Electricity is abstracted from the surface in contact with the pole, while the other surface is positively excited at the expense of any other body with which it may be in contact. Illustrated by a series of panes of glass, coated with tin foil, in communication with each other and the poles.

Q. What means are there for detecting or measuring electricity?

A. By estimating the degree of attraction which light bodies undergo by means of instruments called electrometers.

Q. What are the effects of electricity?

A. The attraction or repulsion of electrified bodies, the extrication of light and heat, and the shock given to the human frame.

Q. Why is it that two bodies, similarly electrified, repel each other?

A. According to the Franklinian doctrine, it is in reality the effect of an attraction between them and the matter of the adjoining medium. It is for the same cause that attraction takes place between bodies differently excited, that they are repelled when similarly electrified.

Q. How is it explained on the theory of two fluids?

A. That the particles of either kind are self repellent.

Q. How is the phenomenon of electrical light illustrated?

A. By having one side of the coated pane left with minute interstices between the tin foil.

Q. Is there a diversity in the appearance of the electric spark?

A. Yes. There is the short straight, and the long zigzag spark.

Q. What causes the zigzag shape of the spark?

A. By the condensation of the air before it, it is obliged to

change its direction; and the large surface to which it is directed, offers no point of attraction, consequently its course changes.

Q. What substances are ignited by the electric spark?

A. Cotton, æther and other combustibles, and hydrogen will explode with oxygen, when mingled in certain proportions.

Q. How is a patient electrified?

A. By placing him on an insulated chair, and in communication with one of the conductors. Being thus negatively or positively electrified, sparks may be taken from any part of the body by a metallic knob or point.

Q. What effect have small points in receiving the electric virtue?

A. The effects of electricity are so mitigated by them that what would produce a shock through a knob, is insensibly received. Hence, the use of pointed rods, as a protection against lightning.

Q. What cautions are necessary in constructing and putting up lightning rods?

A. Its point should be made of platina or other infusible metal; its joints perfect, and its termination with a metallic surface under the earth, or other conducting matter.

GALVANIC ELECTRICITY.

Q. What was the first galvanic observation made?

A. That a peculiar taste was produced when the projecting ends of two metals, one being placed above, the other beneath the tongue, were brought in contact.

Q. Are all metals equally capable of producing this effect?

A. No. It depends on their diversity of oxidization.

Q. What did Galvani subsequently ascertain?

A. That by the same means convulsions were produced in frogs.

Q. How did philosophers account for this fact?

A. By erroneously supposing the nerves and muscles of the animal to be in opposite electrical states, which were neutralized by the conducting power of the metals. Volta detected this error, by demonstrating that these effects resulted from the metals on the animal, and not the animal on the metals.

Q. What is the galvanic pair?

A. It consists of two metals, possessing different powers of oxidization; or several disks may constitute a pair, provided the surfaces of the same be in communication.

Q. Is the form and size of the plates material?

A. No. But it is necessary that they be near and parallel to each other.

Q. What composed Volta's pile?

A. Disks of copper and zinc, alternated with each other and with pieces of moistened cloth, which separated them into pairs, consisting of one disk of each metal. On touching simultaneously the extremities or poles, a shock was experienced.

Q. What was the disadvantage of the Voltaic construction?

A. The supply of moisture was inadequate.

Q. What was the Couronne des Tasses?

A. Disks of copper and zinc, soldered to arches of wire, so as to be consecutively immersed in adjoining tumblers, in the same alternate order as in the Voltaic pile. This was invented to obviate the want of moisture in the Voltaic pile.

Q. What was Cruickshank's contrivance?

A. He made plates of zinc and copper, soldered face to face, to serve as partitions in a trough. Another construction was contrived by Dr. Babington, consisting of a porcelain trough with cells, resembling Cruickshank's trough, but the metallic plates were united by arches of metal so arranged as to be immersed in the acid, and lifted out at pleasure.

Q. What is the most improved construction?

A. Cruickshank's trough, so modified as to allow the acid to be thrown on or off the plates instantaneously.

Q. What is the difference between an electrometer and a calorimeter?

A. The capacity of setting electricity in motion, or the quantity and intensity it produces, is dependent on the number of pairs in the galvanic series; but when arranged in large pairs, its calorific influence is superior.

Q. What was the galvanic theory of Volta?

A. That the contact of dissimilar metals, or their communication through perfect conductors, is the source of galvanic excitement. This doctrine is objectionable, because no ignition is produced until the plates are immersed.

Q. What was the theory of Wollaston?

A. That the chemical action, which consists in the oxidation of the zinc, is the primary cause of the galvanic excitement. As a confirmation of this doctrine, it was observed, that no sensible effect was produced by a combination of conductors which do not act chemically on each other; and that the energy of the pile was in proportion to the corrosion of the metallic plates.

Q. What theory was suggested by Sir Humphrey Davy?

A. That while on the one hand, the contact of two metals of different affinities for oxygen is capable of disturbing the electrical equilibrium, so on the other, it is equally true, that the chemical changes contribute to the result, without which the excitement can neither be considerable in degree, or of long duration; that is to say, the action is begun by the contact of the metals, and kept up by chemical action.

Q. What is a simple galvanic circle?

A. When the two plates, immersed in a liquid, are made to communicate, either by contact or by conducting wires. The electricity generated on the surface of the zinc, in contact with

the fluid, renders the zinc plate positive, and the copper negative. The current is thus directed from the zinc, through the fluid to the copper, and from the copper along the wire to the zinc again.

Q. When the conducting wire is interrupted, which forms the positive pole?

A. That connected with the copper plate. As the plate of zinc is rendered positive at the expense of the wire attached to it, so the latter forms the negative pole.

Q. What are the effects of galvanism?

A. It is capable of producing caloric, light and electricity, as coördinate products, chemical decomposition, and it exerts a peculiar action on the magnet.

Q. What is an example of its producing chemical action?

A. The decomposition of water, by means of the wires of the two poles when immersed in that liquid. The oxygen goes to the positive, and the hydrogen to the negative pole.

Q. What effect has galvanism on magnetism?

A. It communicates the magnetic virtue to iron, steel, &c.

ELECTRO-MAGNETISM.

Q. What analogy is there between electricity and magnetism?

A. That similar poles of a magnet freely suspended recede from each other, and dissimilar poles approach to each other. But electricity and magnetism cannot be identical, as the magnetic needles being perfect conductors of the former fluid, both extremities would be in the same electrical state.

Q. What peculiar effect is produced by the galvanic current on the magnetic needle?

A. When the current passes near the needle the latter as-

sumes a contrary direction. This fact is accounted for on the theory, that when a galvanic current is directed in a right line, the magnetic current will revolve around that line, like the circumference of a wheel around its own axis.

Q. Can electricity be produced by the magnetic current?

A. Yes. Faraday found that a magnetized iron bar may, by alternate introduction, and withdrawing from a coil of wire, produce electrical currents, called Faradian currents.

CALORIC.

Q. What is the received opinion concerning the nature of caloric?

A. That it is a material imponderable fluid, the particles of which are self-repellent, and also attracted by other matter.

Q. What is the effect of caloric on bodies?

A. It produces changes in bulk, and changes in the state of aggregation.

Q. What change does it produce in the bulk of bodies?

A. It expands them.

Q. What change does it produce in the state of aggregation of bodies?

A. It counteracts cohesion so as to cause fusion and the æriform state.

Q. What happens to caloric during the process of fusion?

A. It is absorbed without producing any sensible change in the temperature of the body, in which state it is called latent heat.

Q. How much caloric disappears or becomes insensible during the melting of ice?

A. By taking equal portions of ice and water, the former at the temperature of 32°, the latter at the temperature of 172°,

the ice will be melted, and the resulting temperature will not be a mean, but 32°, thus showing a loss of 140°, which the ice required in melting.

Q. Is the melting or fusing point the same for all substances?

A. No. Ice melts at 32°, mercury freezes at 39° below zero, and alcohol has not been frozen.

Q. What is meant by the boiling point?

A. That point of temperature at which a liquid assumes the gaseous state.

Q. Is the boiling point the same for different liquids?

A. No. Water boils at 212°, alcohol at 176°, æther at 98°, and mercury at 656°.

Q. Does water grow hotter after it boils?

A. No. The principle which the fire communicates is carried off in the steam.

Q. How much caloric is absorbed in producing steam?

A. Near a thousand degrees.

Q. What are the properties of steam?

A. It is an elastic invisible fluid, expanded by caloric, and condensed into water by cold.

Q. What influences the boiling point of liquids?

A. The pressure of the atmosphere. Water boils in vacuo at 72°, alcohol at 36°, and æther would be æriform were it not for the pressure of the atmosphere, thus proving that a liquid is not necessarily hot because it boils.

Q. What advantage has been taken of the fact, that atmospheric pressure influences the boiling point?

A. To ascertain the height of mountains; for every 530 feet ascent the boiling point of water is lowered one degree.

Q. Why is it that the application of cold will cause boiling in a matrass which contains steam and water?

A. In consequence of the condensation of the steam, the

pressure which opposes the boiling is removed, and ebullition ensues.

Q. Are all solids equally expansible by heat?

A. No. Metals are the most expansible solids, but some metals are more expansible than others.

Q. Is there any exception to the law that solids expand by heat?

A. No. The fact that ice and certain metals, in fusing, contract, are not exceptions to the rule as applied to solids. Clay is a supposed, but not a real exception.

Q. Are liquids as expansible as solids?

A. Yes, more so; but some liquids are more expansible than others. Thus, alcohol expands more than water, and water more than mercury.

Q. Do liquids expand equally at all temperatures?

A. No. They expand in an increasing ratio. Dalton conceives that the expansion observes the ratio of the square of the temperature, estimated from the point of congelation.

Q. Is there any exception to the law that liquids expand by heat?

A. Water under 39° expands as it grows cold, and in freezing increases in bulk nearly one-tenth, thus affording a provision for aquatic animals.

Q. What is the cause of the expansion of water at the moment of freezing?

A. The new arrangement of its particles.

Q. Do gases expand by heat?

A. Yes; they are the most expansible bodies.

Q. What peculiarity is there in the expansion of gases?

A. They expand equally by the same additions of caloric, and the same gas expands uniformly at all temperatures.

Q. What is the rationale of expansion?

A. That as the caloric combines with the particles of matter, they acquire its self-repellent power, so as to oppose the force of cohesion; hence, those bodies which are held together by a feeble affinity are most expansible.

Q. By what means can we measure the intensity of heat?

A. By estimating the degree of expansion which substances undergo when subjected to its influence. The instruments employed are called thermometers and pyrometers.

Q. Who invented the thermometer?

A. Sanctoria. He employed as a thermometric substance atmospheric air inclosed in a matrass inverted over water.

Q. Why was Sanctoria's air thermometer objectionable?

A. Because it was influenced by atmospheric pressure as well as temperature.

Q. Have solids ever been employed to measure heat?

A. Yes: clay has been used in Wedgwood's pyrometer.

Q. In what state of cohesion are bodies best for estimating the quantify of heat?

A. Liquids; because solids expand too little, requiring a complicated machinery to be measured, and, gases expand too much.

Q. What liquids are used?

A. Mercury and alcohol.

Q. Which is the best thermometric substance?

A. Mercury; because its expansions are uniform, and its boiling and freezing points are very remote from one another.

Q. For what purpose is alcohol adopted as a thermometric substance?

A. To ascertain very low temperatures, as it has not been frozen.

Q. How do we measure the exact point of temperature?

A. By means of a scale attached to the tube of the thermometer, with the intervals between the freezing and boiling

points of water, divided into any number of equal parts or degrees.

Q. Do all thermometers correspond in the number of divi sions or degrees of the scale?

A. No. Fahrenheit's scale, the one used in the United States and Great Britain, consists of 180, Celsus' of 100, and Reaumur's of 80 equal parts, preserving a relation of 9 : 5 : : 4 to each other. The point of beginning is called zero.

Q. In what respect does the zero of Fahrenheit's thermometer differ from others?

A. Instead of being at the freezing point of water, it is placed at 32° below that point, which makes his boiling point at 212°.

Q. What is the self-registering thermometer?

A. It consists in a mercurial and spirit thermometer, used for determining maximum temperatures.

Q. What is a Differential thermometer?

A. It consists of a tube bent twice at right angles, having some resemblance to the letter U, used for ascertaining the difference in the temperature of the same medium.

Q. Does the thermometer indicate the quantity of heat contained in bodies?

A. No. It only is affected by the sensible heat or free caloric expressed by the word temperature.

Q. What is meant by the term capacity for heat?

A. The relative quantities of caloric required to raise equal weights or bulks of different bodies to the same temperature. This difference in bodies has been called specific heat.

Q. What ensues when the capacity of a body for heat undergoes a change?

A. A change in the temperature of the surrounding medium. If the capacity be diminished heat is produced, if increased the phenomena of cold ensue.

Q. By what means are the capacities of bodies diminished, and heat consequently excited?

A. 1st, by diminution of their bulk; 2d, by chemical agency; 3d, and by certain changes in their state of cohesion.

Q. How is it illustrated that diminution of bulk causes the evolution of caloric?

A. In condensing the atmosphere by means of a condenser, we can ignite spunk or tinder, and by active percussion of any hard body, by which its particles are approximated, heat is produced.

Q. What are examples of heat being produced by chemical means?

A. 1st, combustion; 2d, simple combination, as the union of tin or lead with platina, alcohol and water, sulphuric acid and water; 3d, chemical combination, attended with decomposition, as the explosion of gunpowder; 4th, solution, as nitric acid acting on tin.

Q. What change in the state of aggregation of bodies is attended with evolution of caloric?

A. Gases becoming liquids, and liquids congealing or becoming solid.

Q. What is cold defined to be?

A. Negative heat.

Q. How is cold produced?

A. By the capacities of bodies for heat being increased, so that they extract it from the surrounding bodies.

Q. Why does cold and cloudiness arise from rarifaction?

A. Because the capacity of air for heat is increased, and the consequent production of cold condenses the aqueous vapour.

Q. What are the chemical means of producing cold?

A. By solution of some of the salts, as nitre and nitrate of ammonia, sulphuric acid in dissolving snow, &c. Cold is produced when solids melt, and when liquids become æriform.

Q. In what three modes is caloric communicated?

A. By the processes of radiation, conduction, and circulation

Q. What is meant by radiant heat?

A. Heat communicated in right lines in all directions from heated bodies. The mode in which our rooms are heated by common fire places is a familiar example.

Q. What influences the radiant power of heat?

A. The nature of the radiant body, and the colour of the different surfaces of the same body.

Q. What kind of bodies are best for radiation?

A. Substances which possess porosity; as charcoal, wood, earthenware, &c. Dark coloured surfaces are most favourable for radiating heat.

Q. When the rays of heat fall upon a body what becomes of them?

A. According as the body is more or less porous, they are either absorbed or reflected. The absorption of caloric is inversely as its reflection. For this reason it is that the best absorbers are the worst reflectors, and vice versa.

Q. What class of bodies are good reflectors?

A. The metals. Because the particles are so nearly approximated to each other, or united with caloric, as to leave no passage for radiant heat.

Q. What are good retainers of heat?

A. Metallic bodies, for the same reason that they are good reflectors. Hence good radiators are good absorbers, and good reflectors are good retainers.

Q. Why is a bright metallic tea-pot preferable?

A. Because it is a good retainer of heat.

Q. In what kind of bodies is the conducting power predominant?

A. In solid substances, by which caloric is communicated from atom to atom.

Q. What solids are the best conductors of heat?

A. The metals. Gold, silver, and copper, are the best, and lead is very inferior.

Q. Can you enumerate some of the bad conductors?

A. Bones, ivory, porcelain, glass, wood, charcoal, silk, cotton, wool, &c.

Q. Do liquids conduct heat?

A. Their power for conducting heat is very imperfect.

Q. By what mode do liquids become heated?

A. That of circulation, which implies a free interchange of particles. Heat can only be communicated upwards in a liquid, in consequence of its nonconducting power. When heat is applied to the bottom of a vessel containing water, the lower particles of the liquid expand, and, in consequence of their levity, are compelled to ascend to give place to the colder particles, which, in consequence of their weight, descend, and thus a constant circulation is kept up.

Q. Can you enumerate some of the proximate sources of heat?

A. The sun, electricity, collision, percussion, friction, attrition, chemical agency, fermentation, vitality, &c.

Q. What are the three states in which caloric exists in nature?

A. 1st, As sensible heat, in which it is susceptible of detection by the senses or by the thermometer; 2d, As latent heat, in which it is not susceptible to the above means of detection, but influenced by external changes of temperature; 3d, As it exists in detonating compounds, such as nitrates, chlorates and fulminates, in which peculiar state it is independent of external changes of temperature.

Q. What different opinions have been entertained concerning the nature of the cause of heat?

A. One that it is matter, the other that it is motion. The

former is the generally received doctrine, the latter is supported by Count Rumford and Davy.

Q. What fact gives support to the theory of Davy?

A. The circumstance of heat being produced by friction.

Q. What fact furnishes the best evidence of the materiality of the cause of heat?

A. That it can be radiated in vacuo as well as in pleno, and collected into a focus.

LIGHT.

Q. What is the nature of light?

A. A material elastic fluid, composed of self-repellent particles.

Q. Is light important as a chemical agent?

A. Yes. It is productive of heat, deoxidizement and other chemical phenomena, and is evolved by chemical processes. It facilitates the bleaching process, blackens some salts, and causes the union of hydrogen gas and chlorine gas to take place explosively.

Q. Can you give some of the curious properties of light?

A. Like caloric it is capable of being radiated and reflected; its rays are susceptible of refraction, polarization and dispersion, displaying various colours.

ATTRACTION.

Q. How is attraction divided?

A. Into homogeneous and heterogeneous attraction, the for-

mer takes place between particles of the same kind of matter, the latter between particles of different kinds of matter. For instance, a lump of brass has its particles held together as brass, by homogeneous affinity, but the particles of copper and zinc, which, by their union, form brass, are connected together by heterogeneous affinity. Homogeneous affinity is frequently designated by the terms, attraction of aggregation, attraction of cohesion, and heterogeneous attraction, by the term chemical affinity.

Q. Can heterogeneous, like homogeneous attraction, be overcome by mechanical means?

A. No. We may reduce to powder a compound, but cannot separate its constituent elements by any mechanical process.

Q. When the attraction of aggregation is allowed to take place slowly and regularly, what are produced?

A. Regular shaped masses, called crystals.

Q. Is a crystal capable of being reduced to an indefinite number of primitive forms.

A. No. All crystals have a primitive crystalline form; according to Haüy there are six primitive forms?

Q. Enumerate several modes of obtaining crystals?

A. By fusion, followed by congelation, evaporation, precipitation, and sublimation.

Q. What is essential to the constitution of crystals?

A. Water; called water of crystallisation. Some crystals, on exposure to the air, lose, while others gain, water; the former property is called efflorescence, the latter deliquescence.

Q. Enumerate the different states of aggregation?

A. There are three, viz: solid, liquid, and gaseous.

Q. What causes overcome cohesion or attraction of aggregation?

A. Solution, heat, and mechanical division.

CHEMICAL AFFINITY.

Q. What is chemical affinity?

A. It is that attraction by which the particles of dissimilar matter are united into a compound.

Q. What is the characteristic of a chemical compound?

A. That it partakes of the properties of neither of its constituent elements, but acquires a new and distinct character. Oxygen and nitrogen gas, both harmless ingredients in the air, are capable of forming, when united in certain proportions, one of the most corrosive compounds—aqua fortis.

Q. Enumerate some of the phenomena that attend chemical action.

A. Changes of density, temperature, state of aggregation and colour.

Q. Are there several cases of affinity?

A. Yes. According to Dr. Hare there are four cases.

Q. Illustrate the first case of affinity?

A. It is where two substances unite to form a compound; for instance, copper and zinc form brass, acids and alkalies form salts. This is called simple combination.

Q. Illustrate, with an example, the second case of affinity?

A. It is when two substances being in union we add a third, which unites with one of them to the exclusion of the other, as sulphate of magnesia (epsom salt) is decomposed by potash; in consequence of the superior affinity of the latter for the sulphuric acid of the sulphate, the magnesia is precipitated. This case is called *single elective attraction* or *simple affinity*.

Q. Define, with an example, the third case of affinity?

A. It is where two compounds mutually decompose each other; as sulphate of zinc, being mixed with acetate of lead,

forms sulphate of lead and acetate of zinc. This is called *double elective attraction* or *complex affinity.*

Q. Illustrate, with an example, the fourth case of affinity?

A. It is where two substances being in union, a third being added in excess combines with both; for instance, ammonia, on being added in excess to some metallic salts, as those of copper or silver, unites both with the acid and the metal.

Q. Enumerate some of the causes which influence or limit chemical action?

A. Cohesion, solution, temperature, pressure of the atmosphere, quantity of matter or relative proportions, and specific gravity.

Q. Can you give an example of the influence of cohesion as an opponent to chemical action?

A. If a ball of brass be put into one glass and only half its weight of brass filings into another, on adding nitric acid to both, a violent effervescence ensues in the one, while in the other the reaction will scarcely be discoverable.

Q. Can you furnish an example of the influence of solution over affinity?

A. Tartaric acid and a carbonate, pulverised and intimately mingled, are observed not to react until moistened, when violent action ensues.

Q. Can an exception be furnished to the rule that fluidity is required for chemical action?

A. Yes. By mixing slacked lime and muriate of ammonia together in powder, the pungent fumes of ammonia are quite observable.

Q. Can you give an example of the influence of temperature over chemical affinity?

A. Epsom salts will dissolve only to a certain extent in cold water, but when heat is applied the solution will go on still

further. Some substances, as the alkaline earths, are more soluble in cold than boiling water.

Q. How is the influence of atmospheric pressure over chemical affinity demonstrated?

A. When a gaseous substance ceases to escape from combination under ordinary pressure, if that pressure be removed, chemical action will again go on, and more of the gaseous matter will be extricated.

Q. Can an example be furnished of the influence of relative proportion or quantity of matter over chemical action?

A. Of the three oxides of lead, the peroxide parts most easily with its oxygen by the action of caloric, while the protoxide will bear the strongest heat of our furnaces without losing a particle of oxygen; so that that compound will be the most difficult of decomposition which contains the smallest quantity of oxygen.

Q. How do you illustrate the influence of gravity over affinity?

A. When metallic bodies are in combination, the heaviest metal is not unfrequently found in the bottom of the metallic mass.

ATMOSPHERIC PRESSURE.

Q. How is it demonstrated that the air is possessed of weight?

A. By allowing it to enter an exhausted glass globe while accurately counterpoised upon a scale beam, the latter is made to preponderate.

Q. What is the average weight of the air?

A. Equal 15 pounds for every square inch. According to the torricellian experiment, it is demonstrated that the pressure of the atmosphere on mercury on the outside of a tube unbalanced by the like pressure within, will cause a column of that liquid

to be supported at the height of thirty inches. Consequently the mercury in the tube is equal the weight of the air which it balances. To prove the truth of this allegation, it is only necessary, by means of an air pump, to remove the pressure on the outside of the tube, and the mercurial column unbalanced by external pressure subsides.

Q. How high will the pressure of the atmosphere support a column of water in a tube exhausted of air?

A. Thirty-three or thirty-four feet. It is upon this principle that the water pump operates; the admission of the atmosphere being indispensable, as well as the exhaustion of the tube. A column of mercury thirty inches in height will precisely balance a like column of water 34 feet.

Q. By what means is the pressure of the atmosphere generally determined?

A. By the height at which a column of mercury is sustained. The instruments employed are called barometers. The barometric pressure varies from 28 to 31; average 30.

Q. Supposing the air to be of uniform density throughout, can we calculate its height?

A. By multiplying the specific gravity of mercury by the height at which the mercurial column is supported, will give the height of a column of water equal to 34 feet. On the same principle we may calculate the height of the air.

Q. Is the air of uniform density throughout?

A. As its pressure causes its density, in elevated situations density is diminished. At 30 miles height it is supposed to be as rare as can be made by the air pump.

Q. What influence does the pressure of the atmosphere exert over the boiling point of liquids?

A. They boil in vacuo 140° lower than in the open air. Thus water boils in vacuo at 72°, alcohol at 36°, and æther at 42° below zero.

Q. What influence does it exert over chemical action?

A. It limits it so as to prevent the escape of gaseous substances from combination.

Q. What other mechanical properties does the air possess?

A. It is compressible, elastic, and its specific gravity is made unity or the standard of the gases.

Q. How can we demonstrate the elastic reaction of air?

A. By placing an air-tight bottle on the receiver of an air pump, and exhausting the receiver, when the air on the inside of the bottle rushes to restore the equilibrium with a force sufficient to fracture it.

Q. What is the difference between the air and water pump?

A. The only difference between pumping air and water arises from the nature of these fluids; in the former process air rushes out by its own elasticity, in the latter water is forced out by atmospheric pressure.

Q. Is the bulk of air subject to change?

A. Yes. It is influenced by temperature as well as pressure. The resistance of the air is in proportion to its compression.

Q. Is the air of uniform temperature throughout?

A. No. It varies with the elevation. It is lessened one degree for every three hundred feet.

Q. How is this fact accounted for?

A. There are two causes. The air receives its caloric from the earth, and the rarified air possesses a greater capacity for heat.

LAWS OF COMBINATION.

Q. Do the proportions with which one substance combines with another, influence the force of attraction?

A. Yes. Attraction may be divided into feeble and energetic affinity, according as the elements of the compound are united

in many or few proportions. Feeble affinity is displayed in those compounds whose elements are united in many proportions; while that class of combinations, the elements of which unite in a few proportions only, display an energetic affinity.

Q. Can you give examples of substances in combination which display a feeble affinity?

A. The union of water and alcohol, and the union of sulphuric acid and water, afford instances in which combination takes place in every proportion and without limit. Solution is an instance of union in every proportion within a certain limit, which limit is the point of saturation.

Q. Can you give examples of those compounds whose elements are united by an energetic affinity, and in few proportions?

A. Chlorine and hydrogen unite in only one proportion; hydrogen and oxygen in two proportions; other substances unite in three, four, and even five or six proportions. This class of compounds form the most interesting series, and possess the properties of neither of their constituent elements.

Q. What laws regulate these compounds?

A. There are three; namely—1st. Bodies unite in definite proportions. 2d. They unite in progressive proportion, which obey the law of multiples. 3d. They unite in equivalent proportions.

Q. What is meant by definite proportions?

A. That bodies unite in fixed and invariable proportions. For instance, water is composed of eight parts of oxygen to one of hydrogen; and in no other proportions could these elements form water.

Q. Can you illustrate the meaning of progressive and multiple proportions?

A. When substances unite in two or more proportions, the several proportions with which one body combines with another,

are in the ratio of 1, 2, 3, 4, 5. For instance, oxygen unites in the following proportions, with one proportion of nitrogen, viz: to form nitrous oxide, 1 atom weighing 8; nitric oxide, 2 atoms weighing 16; hyponitrous, 3 atoms weighing 24; nitrous acid, 4 atoms weighing 32; and nitric acid, 5 atoms weighing 40—thus, 8 being divided into 40, will be a multiple of the whole number five without a fraction. This law leads to the atomic theory.

Q. What is meant by equivalent proportions?

A. That the number which represents the proportion with which one body is capable of combining with another, is also the representative of the proportion in which the same body combines with every other; that is to say, that bodies combine in reciprocating ratios. For instance, 8 parts of oxygen unite with 1 of hydrogen, with 16 of sulphur and 36 of chlorine; and the 16 of sulphur is the exact quantity for union with 1 of hydrogen and 8 of oxygen, and 36 of chlorine—thus showing that the weights of the combining proportions of these bodies are equivalent one to another.

Q. Do the equivalent numbers represent absolute weights?

A. No. Only the relative weights of the combining proportions.

Q. How are the union of bodies in definite and multiple proportions accounted for?

A. By admitting the atomic theory to be correct, which supposes that the ultimate particles, called atoms, possess in different substances different weights; and that when bodies unite, it is the atoms which combine with one another.

Q. What is understood by the theory of volumes?

A. It is the relative or equivalent bulks in which bodies combine together, called also combining volume.

Q. As bodies combine in equivalent weight, does it follow

as a necessary consequence that the equivalent bulks should correspond?

A. No. For instance, the combining proportion of oxygen is eight times heavier than hydrogen, yet the hydrogen occupies twice the volume.

Q. Are the combinations of bodies in volumes like the combining weights in multiple proportions?

A. Yes. According to the hypothesis of Gay-Lussac, substances, when æriform, unite in volumes which are equal; or that when unequal, the larger volume is double, triple, or quadruple the other. The numbers which represent the combining volumes, do not run as high as those of the combining weights.

Q. What peculiarity is there in the combining bulks of gases?

A. A great number of them possess the same combining volume which indicates an equal magnitude of the atoms. For instance, chlorine, hydrogen, nitrogen, carbonic acid and cyanogen, combine in equal volumes. Oxygen possesses only half the volume of the above list, while muriatic acid and ammonia occupies twice the volume.

Q. If we call the combining volume of oxygen, unity, what is hydrogen and ammonia?

A. Hydrogen would be two, and the number for ammonia four. For convenience, it is best to make that number unity in bulk which represents so many gaseous substances.

Q. Are the combining volumes absolute or relative?

A. Relative. Hence it is immaterial what we make the number for the combining volumes, so we preserve their relations. As nearly all the gases are uniform in combining bulk, it is most convenient to make them unity. Thus oxygen would be represented by one half a volume, hydrogen and chlorine one volume, and ammonia two volumes, as their combining bulks.

SPECIFIC GRAVITY.

Q. What is understood by the term specific gravity?

A. It is the relative weights of equal bulks of different bodies.

Q. How is the specific gravity of a body ascertained?

A. As water is assumed to be the standard or unity, it is only necessary to divide the weight of the body by the weight of a like bulk of water.

Q. How is the difficulty of obtaining equality of bulk in order to find specific gravities obviated?

A. Since a body, when sunk in water, will displace precisely its own bulk of that liquid, and as the weight of the bulk of water displaced is equal to the resistance which the body encounters in sinking, we have only to divide the weight of the body by what it loses of its weight in water, to get the specific gravity.

Q. How do we obtain the specific gravity of a body lighter than water?

A. As the resistance to its sinking in water, added to what is necessary to overcome that resistance, is equal to the weight of a like bulk of that liquid, we proceed by dividing the weight thus obtained into the weight of the body.

Q. How ascertain the specific gravity of any liquid?

A. By dividing the resistance which a body encounters in sinking into the liquid in question, by the resistance to its sinking in water.

Q. What are hydrometers?

A. Hydrometers are instruments for ascertaining the relative resistances which different liquids offer to the sinking of a body in them, estimated by means of a graduated scale. The gra-

duation commences at the top of the scale for liquids heavier than water, and at the bottom for liquids lighter than water.

Q. How are obtained the specific gravities of gases?

A. By filling a glass globe with any gaseous body, and weighing it. As the atmosphere is the unit, we obtain the specific gravity of a gas by dividing the latter by the former.

Q. Why is it that one substance is possessed of more weight than another?

A. Either because the particles differ in weight, or it is dependent on the degree of their approximation creating more or less interstitial space.

Q. How does it happen that a pound of feathers is heavier than a pound of lead?

A. Because when a body is suspended in a fluid it is resisted in proportion to the weight of the fluid, and the quantity displaced by the body. Consequently, the more space it occupies, in proportion to its weight, the more will its weight be counteracted. Hence, on removing atmospheric pressure, the pound of feathers will preponderate.

SIMPLE INORGANIC SUBSTANCES.

Q. What is the number and classification of the simple bodies?

A. They are fifty-four in number. They are classified, according to Dr. Hare, into *basacigen substances* and *radicals*.

Q. What is implied by the term *basacigen substances?*

A. They are those elements which produce both acids and bases, by combining with the remaining elements.

Q. Enumerate the basacigen substances?

A. They are eight in number, as follows, viz: Oxygen, Chlorine, Bromine, Iodine, Flourine, Sulphur, Selenium and Tellurium.

OXYGEN.

Q. In what docs oxygen gas exist?

A. It is a universal constituent of animal and vegetable substances. It constitutes one-fifth of the bulk of the air, and one-third of the bulk of water.

Q. Why called oxygen?

A. Derived from the Greek word signifying to produce acid; from the impression of its being the sole acidifying principle.

Q. How is it procured?

A. By depriving an oxide of its oxygen by heat. On account of its cheapness the tritoxide of manganese is used. Other substances which, when heated, part with oxygen, may also be employed for the purpose, such as nitre, chlorate of potash, &c.

Q. What are the properties of oxygen?

A. It is an insipid, inodorous, colourless, and transparent gas, but slightly absorbed by water, combines with bodies forming either ordinary oxides, acids, or alkalies, an active supporter of combustion, and is an indispensible agent in supporting life.

Q. How is its activity as a supporter of combustion proved?

A. By its burning sulphur, phosphorus, and intensely that of iron wire. The result is sulphurous and phosphoric acids, and oxide of iron.

CHLORINE.

Q. In what does chlorine exist?

A. It constitutes three-fifths of common salt, (chloride of sodium,) forms one-fiftieth of the matter in the ocean, and is disseminated throughout the land.

Q. By whom was it discovered?

A. Scheele, in the year 1770, made the discovery. He gave it the name of dephlogisticated marine acid.

Q. What was the opinion entertained by the French chemists of the nature of chlorine?

A. That it was a compound of muriatic acid and oxygen, an opinion proposed by Berthollet. Its compound nature was first denied by Sir H. Davy, who ranked it among the simple bodies. From its colour, he gave it its present name.

Q. How is chlorine procured?

A. There are several modes of obtaining chlorine. It may be obtained by the action of muriatic acid on peroxide of manganese. Muriatic acid is decomposed; its hydrogen uniting with the oxygen of the oxide forms water, and its chlorine escapes. Generally procured from chloride of sodium, which is heated in a glass or leaden retort, with diluted sulphuric acid and peroxide of manganese. The water of the acid is decomposed, the oxygen uniting with sodium to form soda, with which part of the acid combines, forming sulphate of soda. The hydrogen of the water is retained by the oxygen furnished from the oxide of manganese, while the chlorine alone is allowed to escape.

Q. What are the properties of chlorine?

A. It is a permanent gas of a greenish yellow colour, absorbed by water, rendered liquid by great pressure, irrespirable, capable of exciting the sensation of warmth, and is an active supporter of combustion.

Q. Of what utility is chlorine?

A. It forms some of the most active medicinal and corrosive

compounds; it is a powerful disinfecting agent, and very important for the purposes of bleaching.

Q. How do you explain the rationale of its bleaching power?

A. Hydrogen of water unites with the chlorine, and the decomposition of the colouring matter is occasioned by the oxygen which is liberated. Hence the presence of water is required for bleaching, which is decomposed, and muriatic acid is formed by the union of hydrogen and chlorine.

Q. What is formed by the action of chlorine on the metals?

A. Chlorides of metals. It is the only solvent of gold.

Q. What is its equivalent number and specific gravity?

A. Its equivalent is represented by 36; its specific gravity by 2.5.

Q. What is the best test for chlorine?

A. Silver in solution; which causes a dense white precipitate of chloride of silver.

Q. How many compounds are there of chlorine and oxygen?

A. Four; two oxides, a protoxide and peroxide; and two acids, chloric and perchloric acids.

Q. How is the protoxide of chlorine procured?

A. By the action of muriatic acid on the chlorate of potash. Part of the muriatic acid, by its affinity for the potash, disengages chloric acid, which, reacting with the remainder of the muriatic acid, results in chlorine, protoxide of chlorine, and water. The two gases escape, and the chlorine unites with the mercury over which the protoxide is collected.

Q. What are the properties of protoxide of chlorine?

A. It is a gas of a greenish yellow colour, very absorbable by water, detonates by the warmth of the hand, occupying one-fifth more space, and explodes with antimony, which is very attractive for chlorine.

Q. How is the peroxide of chlorine procured?

A. By the action of sulphuric acid on chlorate of potash.

The superior affinity of the acid for the potash displaces the chloric acid, and as the latter cannot exist in an isolated state it is decomposed into oxygen gas and peroxide of chlorine.

Q. What are its striking properties?

A. It is a gas of a yellowish colour, and very explosive.

Q. How is chloric acid procured?

A. By adding to a dilute solution of chlorate of baryta a quantity of dilute sulphuric acid, sufficient to saturate the baryta; the insoluble sulphate of baryta subsides, and chloric acid remains in solution.

Q. What are its peculiarities?

A. It possesses no bleaching properties, and gives no precipitate with nitrate of silver. It is easily decomposed.

Q. How is perchloric acid obtained?

A. By the action of sulphuric acid on perchlorate of potash. This salt is left in the retort, when we get peroxide of chlorine.

Q. What is the composition of the compounds of oxygen with chlorine?

A. The protoxide consists of 1 atom of each element; in volume, 1 volume of chlorine to $\frac{1}{2}$ a volume of oxygen, condensed into $1\frac{1}{4}$ volumes. The peroxide of 1 atom of chlorine to 4 atoms of oxygen, chloric acid, of 1 atom of chlorine to 5 of oxygen and perchloric acid, 1 atom of chlorine to 7 of oxygen.

BROMINE.

Q. Where is Bromine found to exist?

A. In sea water in the state of bromohydric acid, combined with magnesia as a bromohydrate.

Q. How is it procured?

A. By passing chlorine into sea water. The chlorine unites with the hydrogen, which produces muriatic acid, and we have

muriate of magnesia formed, and a solution of bromine displaced. Then wash the solution with æther, and treat the æthcrial solution with potash, which results in bromide of potassum, from which bromine is obtained precisely as chlorine is from the chloride of sodium.

Q. Can you give the properties of bromine?

A. It is a liquid of a dark reddish colour, very volatile, in odour like chlorine; absorbed by water, alcohol and æther, vapourised at 137 degrees, and freezes at 13 degrees below zero.

Q. What are compounds with bromine?

A. With oxygen it forms bromic acid, with hydrogen bromohydric acid, and with metals, bromides.

Q. How is bromine in most cases detected?

A. By means of chlorine, which displaces it from its combinations.

IODINE.

Q. By whom and when was Iodine discovered?

A. By Courtois, a manufacturer of saltpetre at Paris, in the year 1812.

Q. How is it obtained?

A. By the action of heat and sulphuric acid on the residue that is left in manufacturing carbonate of soda from kelp. It comes over in a beautiful violet vapour.

Q. Can you give the properties of iodine?

A. It is a solid of a blueish-black colour, acrid, and stains the skin yellow. It is a crystalline powder, fusible at 225 degrees, and volatilised at 350; it is not combustible in oxygen or the air, and almost insoluble in water. Equivalent, 124.

Q. What are solvents of iodine?

A. Alcohol and æther.

Q. What is the best test for iodine?

A. Starch, with which it forms an intense blue colour.

Q. What are some of the compounds of iodine?

A. With oxygen it forms iodic; with chlorine, chloriodic; with hydrogen, idohydric acid, and with metals it forms iodides.

SULPHUR.

Q. In what state does sulphur exist in nature?

A. It is found pure, and widely disseminated in combination with metals, as a sulphide.

Q. In what kind of countries does it occur as native sulphur?

A. In the vicinity of volcanoes. The most common mines are in Naples, Sicily, and the Roman states.

Q. How is sulphur obtained?

A. By the application of heat to crude sulphur, or to some of the sulphides, by which it is either fused and run into moulds, constituting what is called roll sulphur, (brimstone,) or sublimed, forming the flowers of sulphur.

Q. What are the properties of sulphur?

A. It is a solid, of a pale-yellow colour, when sublimed; of a crystalline structure, nearly insipid, inodorous unless when rubbed, or heated; rendered electric by friction, is a bad conductor of heat, very volatile, being capable of undergoing a slow combustion at 180 degrees, and soluble in boiling oil of turpentine.

Q. When subjected to certain temperatures, what peculiar changes does sulphur undergo?

A. At 180° it volatilises, at 225° it melts, between 350° and 400° it thickens, when exposed to 560° it takes fire, but if confined in close vessels at 600° it sublimes.

Q. Does sulphur support combustion?

A. An iron wire burns in it, forming sulphide of iron.

Q. In what form is sulphur sold in the shops?

A. As rolls, flowers, and precipitated or Lac sulphuris.

Q. How is Lac sulphuris obtained?

A. By precipitation of sulphur from a solution of sulphuret of lime, made by boiling sulphur and lime together by means of an acid. The acid, by uniting with the alkali, precipitates the sulphur as a hydrate.

Q. Will any acid answer equally well?

A. Muriatic acid should be used, because the muriate of lime is soluble. Other acids from forming insoluble salts with lime, should not be used, as they would be precipitated with the sulphur.

Q. How can crystals of sulphur be formed?

A. By fusion followed by congelation.

Q. With what does sulphur combine?

A. Oxygen, chlorine, iodine, bromine, hydrogen, metals, and metallic oxides, &c.

Q. What are the compounds of sulphur and oxygen?

A. Sulphuric, hypo-sulphuric, sulphurous, and hypo-sulphurous acid.

SULPHUROUS ACID.

Q. How is sulphurous acid obtained?

A. By the ordinary combustion of sulphur, or by boiling sulphuric acid on sulphur, mercury, or any deoxidizing agent.

Q. What are the properties of sulphurous acid?

A. It is a gas, irrespirable—does not support combustion, bleaches silk and wool, whitens litmus, and is very absorbable by water.

Q. What is the atomic composition of this gas?

A. One atom of sulphur with two of oxygen.

SULPHURIC ACID.

Q. How is sulphuric acid obtained?

A. By burning sulphur and nitre over a stratum of water in chambers lined with lead; or by the old process of distilling green vitriol.

Q. How do we explain the rationale for obtaining sulphuric acid by burning sulphur with nitre?

A. The nitric acid of the nitre yields three atoms of oxygen to a portion of sulphur, and converts it into sulphuric acid which combines with the potash of the nitre; while the greater part of the sulphur forms sulphurous acid by uniting with the oxygen of the air. The nitric acid, in losing three atoms of oxygen is converted into nitric oxide, which, by mixing with air, gives rise to nitrous acid red fumes. By the assistance of aqueous vapour, a white crystalline compound is formed, which is composed of water and the two acids. This crystalline solid is decomposed by the water at the bottom of the chamber into sulphuric acid and deutoxide of nitrogen, and the latter meeting with the air of the chamber takes oxygen, and becomes again nitrous acid. As the process goes on, by the aid of heat and air, more nitrous and sulphurous acid is formed, which, combining with the aqueous vapour, results in the formation of more of the crystallized compound, which, being decomposed again, more sulphuric acid and nitric oxide continue to be formed.

Q. What is the alleged composition of this crystalline solid?

A. Two atoms of sulphuric acid, with one atom of nitrous

acid, and a small quantity of water. This composition is inferred from the fact, that the quantity of oxygen required to convert the two equivalents of sulphurous into sulphuric acid, is precisely that which one equivalent of nitrous acid loses in being converted into nitric oxide.

Q. What are the properties of sulphuric acid?

A. It is a liquid of an oleaginous consistence—it separates all other acids from alkalies, is caustic, and absorbs moisture by its very strong affinity for water.

Q. What effect is produced when mixed with water in certain proportions?

A. A remarkable elevation of temperature.

Q. What is the best test?

A. Baryta, forming the insoluble sulphate of baryta.

Q. What is the composition of sulphuric acid?

A. One atom of sulphur to three atoms of oxygen.

Q. What is the old name for this acid?

A. Oil of vitriol, from the circumstance of its being obtained from green vitriol.

SELENIUM.

Q. What is selenium?

A. A newly discovered substance, its properties being intermediate to sulphur and the metals, and is found in volcanic rocks, in union with them.

Q. What are the properties of selenium?

A. It is a solid, of a lead colour, insipid, a bad conductor of heat and electricity, and is not rendered electric by friction. Heated before the blowpipe, it tinges the flame of an azure blue, and emits the smell of horse radish.

Q. Are there compounds of selenium?

A. Yes. There is an oxide, acid, a chloride, and a compound with hydrogen.

TELLURIUM.

Q. Where is tellurium found?

A. It is a very rare substance found in the mines of Transylvania.

Q. What are the striking properties of tellurium?

A. It is a bright tin colour, fusible below a red heat, and volatile above that point; heated before the blowpipe it burns with a greenish blue flame, and forms compounds with oxygen and hydrogen.

RADICALS.

Q. What are radicals defined to be?

A. Radicals are bodies capable of forming, with a basacigen body, either an acid or a base, or both, and which do not form acids or bases with each other.

Q. Enumerate the nonmetallic radicals?

A. Hydrogen, nitrogen, phosphorus, carbon, boron, silicon, and zirconion.

HYDROGEN.

Q. In what does hydrogen exist?

A. In water; and it is a principal constituent of ordinary flame.

Q. How is hydrogen procured?

A. By the decomposition of water, either by passing steam over turnings of iron made red hot in a gun barrel, or by the reaction of dilute sulphuric or muriatic acid on turnings of iron or zinc. In the former case, the oxygen combines with the metal, while the hydrogen escapes; in the latter, the water of the sulphuric acid is decomposed; the oxygen oxidizes the metal, with which the acid combines to form a salt, while the hydrogen escapes.

Q. What are the properties of hydrogen?

A. It is, when pure, an insipid, inodorous and colourless gas, never rendered liquid, does not support life, nor combustion—it is pre-eminently inflammable, and possesses a high capacity for heat, sparingly absorbed by water—and it is the lightest of all ponderable substances. The equivalent of hydrogen is unity.

Q. If mixed with oxygen, or atmospheric air, in certain proportions, and subjected to the electric spark, what happens?

A. It explodes. The hydrogen to the oxygen must be in the proportion of two to one to form an explosive mixture.

Q. What are some of the compounds of hydrogen?

A. With oxygen it forms water; with chlorine, chlorohydric acid; with iodine, idohydric; with sulphur, sulphydric acid; with nitrogen, ammonia; and with cyanogen, cyanhydric, or prussic acid.

Q. For what does hydrogen display a strong affinity?

A. Caloric. So that it cannot, per se, be separated from it.

Q. What advantage has been taken of the levity of this gas?

A. The formation of balloons. Its specific gravity is .0694.

Q. Can water be obtained by artificial means?

A. Yes. It is produced by the combustion of oxygen gas with hydrogen gas?

Q. What are the properties and uses of water?

A. It is very important as a solvent, and is essential to some

crystals and to galvanic processes. Water unites with earths and alkalies, producing heat during combination with them, which results in compounds called hydrates.

Q. Is there air in water?

A. Yes. Fishes cannot live in water which, either by boiling or exhaustion, is deprived of air.

Q. What is the composition of water?

A. It consists of 1 atom of hydrogen to 1 atom of oxygen: or, in volumes, of 1 volume of hydrogen to half a volume of oxygen; equivalent number 9.

Q. Does hydrogen or oxygen combine in any other proportion?

A. Yes. So as to form deutoxide of hydrogen.

Q. How procured?

A. By dissolving deutoxide of barium in muriatic acid liquid, precipitating the barytes by sulphuric acid and the chlorine by silver.

Q. What are the peculiar properties of deutoxide of hydrogen?

A. It is a colourless liquid—nearly inodorous metallic taste—produces a smarting sensation on the skin—more difficult to vapourize than water, and gives off oxygen explosively with some substances, such as silver, gold, &c.

Q. What happens if hydrogen and chlorine be mixed together in equal volumes?

A. They combine spontaneously, and form chlorohydric acid, (muriatic acid.)

Q. Does the light influence this union?

A. Yes. For in the dark it takes place slowly, but in the solar rays explosively.

CHLOROHYDRIC, OR MURIATIC ACID GAS.

Q. How is chlorohydric acid procured?

A. By the action of sulphuric acid on chloride of sodium with heat. The water of the sulphuric acid is decomposed; its oxygen unites with the sodium, forming soda, with which the sulphuric acid combines, forming sulphate of soda. The hydrogen of the water, and the chlorine, escape as muriatic acid.

Q. What are the properties of muriatic acid?

A. It is a colourless gas, irrespirable, does not support combustion, very absorbable by water, decomposed by the alkaline metalloids, and produces white fumes if allowed to escape into the air, in consequence of combining with moisture, for which it has a remarkable affinity.

Q. What is the composition of this gas?

A. 1 atom of hydrogen to 1 atom of chlorine, or one volume of each resulting in two volumes. Equivalent number is 37.

Q. How is liquid chlorohydric acid obtained?

A. By saturating water with the gas in Woulfe's apparatus.

Q. What are the properties of liquid muriatic or chlorohydric acid?

A. When pure, colourless; generally straw coloured, from containing a minute portion of iron. It unites with those alkalies, earths, and oxides only, which form with it soluble salts.

Q. What effect has heat and desiccation on its combinations?

A. It converts them into chlorides. Muriates of magnesia and alumina are exceptions.

Q. Is there a chloride of ammonia?

A. No. Chlorine decomposes it by its affinity for hydrogen.

Q. What was the old theory of muriatic acid?

A. It was deemed a compound of oxygen with some un-

known radical. When distilled with red oxide of lead, or peroxide of manganese, oxygen was supposed to combine with it, forming oxygenated muriatic acid, the name then given to chlorine.

Q. How did they account for the activity of chlorine as a supporter of combustion?

A. To the oxygen imagined to exist in it.

Q. What did really happen in all those processes in which muriatic acid was thought to receive oxygen?

A. It was deprived of hydrogen.

Q. How is it proved that oxygen is not a constituent of chlorine?

A. Charcoal, even when ignited by the voltaic pile, is not acted upon by dry chlorine, nor are metals oxidized thereby.

Q. How may idohydric acid be procured?

A. By transmitting hydrogen and vapour of iodine through a red hot tube. Or by the action of water on iodide of phosphorus, the former being decomposed, the oxygen unites with phosphorus to form phosphoric acid, and the hydrogen with iodine forming idohydric acid, which passes over.

Q. What are the properties of this substance?

A. It is a gas possessing acid properties, produces dense white fumes with the air, and has an odour not unlike muriatic acid gas. It is very absorbable by water, and combines with alkalies forming idohydrates.

Q. How is bromohydric acid procured?

A. By mixing the vapour of bromine with sulphuretted hydrogen.

Q. What are the compounds of hydrogen with sulphur?

A. Sulphydric acid (sulphuretted hydrogen) and the polysulphide of hydrogen.

SULPHYDRIC ACID.

Q. How is sulphydric acid obtained?

A. By the action of diluted sulphuric acid on a sulphide. Sulphide of iron is mostly employed in a contrivance called the self regulating reservoir. Water is decomposed, the oxygen uniting with iron, with which the sulphuric acid combines while the hydrogen, with the sulphur, escapes as sulphydric acid. It is also found native in some mineral waters, and is evolved from privies.

Q. What are the properties of sulphuretted hydrogen?

A. It is a gas, with the odour of rotten eggs, irrespirable, does not support combustion, inflammable, burning with a pale blue flame, and absorbable by water.

Q. For what class of substances is sulphydric acid a test?

A. The metals forming with them sulphides. All metallic solutions, however, are not decomposed by this acid, of which iron, nickel, cobalt, manganese, titanium, and molybdenum furnish examples.

Q. What is the best test for sulphydric acid?

A. Lead, forming a black sulphide.

Q. What is the composition of this gas?

A. Sulphur and hydrogen, each one atom.

Q. What does hydrogen form with selenium and tellurium?

A. With the former selenhydric acid, commonly called seleniuretted hydrogen; with the latter, telluhydric acid, known as telluretted hydrogen.

NITROGEN.

Q. In what does nitrogen exist?

A. In the atmosphere, forming four-fifths of its bulk. Its ponderable base is a principal element in animal matter.

Q. How is nitrogen procured?

A. By the decomposition of the atmosphere with any substance which will in a close vessel abstract oxygen from the included portion of air; as, for instance, by the combustion of phosphorus, or by iron filings, and sulphur moistened.

Q. What are the properties of nitrogen?

A. It is a gas, distinguished by a comparative want of properties. It does not support life nor combustion. Its most distinguished property is its strong affinity for caloric, so as to carry it into combination with it. Its equivalent number is 14; specific gravity, 0.9722.

Q. In what peculiar substances is nitrogen an ingredient?

A. A majority of the most fulminating compounds.

Q. Is the air a compound or mixture?

A. It is a mixture, having no properties of a compound?

Q. What is the composition of the air?

A. Composed of nitrogen near four-fifths; oxygen near one-fifth, a little carbonic acid, aqueous vapour, and near the sea supposed to be a little muriatic acid.

Q. What is that science called, the object of which is the analysis of the air?

A. Eudiometry. Hydrogen is generally employed as a eudimetrical substance or agent, which, on being subjected to the electric spark, unites with the oxygen to form water.

Q. Can you give the process of analyzing the air?

A. Take a given quantity of air, and add enough hydrogen

to convert all the oxygen present into water. The oxygen and hydrogen having disappeared, form the deficit, which, being divided by three, will give the quantity of oxygen present in the given number of measures of the atmosphere.

Q. What is the composition of the atmosphere in atoms and in volumes?

A. Composed of two atoms of nitrogen to one of oxygen; and in volumes, two of nitrogen to half a volume of oxygen, which results (being no condensation) in two and a half volumes. Equivalent, 36.

COMPOUNDS OF NITROGEN AND OXYGEN.

Q. What are the compounds of nitrogen and oxygen?

A. There are five compounds; namely, nitrous oxide, nitric oxide, hyponitrous acid, nitrous acid, and nitric acid.

Q. How is nitrous oxide procured?

A. By the action of dilute nitric acid on zinc, or by exposing nitric oxide to iron filings. The best mode is to subject nitrate of ammonia to destructive distillation. Three equivalents of oxygen from the nitric acid, with three equivalents of hydrogen of the ammonia, form water, while the two equivalents of nitrogen which is left from the ammonia and nitric acid, unites with the remaining two equivalents of oxygen to form two equivalents of nitrous oxide. Hence the residue is water and nitrous oxide.

Q. What are the properties of nitrous oxide?

A. It is an invisible gas, supports combustion, rendered liquid by great pressure, absorbed by water, and when respired productive of a peculiar transient inebriety.

Q. What is the composition of nitrous oxide?

A. Nitrogen and oxygen each one atom; in volumes, one of

nitrogen to half a volume of oxygen. Its proper name is protoxide of nitrogen.

Q. How is nitric oxide procured?

A. By the reaction of nitric acid on copper, silver, or other metals, by means of the self regulating reservoir.

Q. What are the properties of nitric oxide, or deutoxide of nitrogen?

A. It is an invisible gas, slightly absorbed by water, supports the combustion of some combustibles, but extinguishes a candle flame; irrespirable, explodes with ammonia, and on account of its distinguishing property of combining with the oxygen of the air, forming red fumes, it is impossible that it should exist where the atmosphere has access.

Q. What does it form by union with the atmosphere?

A. Nitrous acid red fumes.

Q. What is the composition of nitric oxide?

A. It consists of one atom of nitrogen to two atoms of oxygen, and one volume of each resulting in two volumes of deutoxide of nitrogen, without condensation.

Q. How is nitrous acid formed?

A. By mixing two volumes of deutoxide of nitrogen with one volume of oxygen?

Q. What are the properties of nitrous acid?

A. It is a gas, of a green orange colour, irrespirable, and supports combustion?

Q. To what scientific purpose has nitric oxide been appropriated?

A. As a eudimetrical substance.

Q. How do you explain the analysis of the air by nitric oxide?

A. Nitric oxide uniting with oxygen forms nitrous acid which, being absorbed, forms the deficit. As nitrous acid consists of three volumes, one of oxygen and two of deutoxide of

nitrogen, dividing the deficit by three will give the quantity of oxygen in the given measures of the air.

Q. What is the atomic composition of nitrous acid?

A. One atom of nitrogen to four of oxygen.

Q. What is the composition of hyponitrous acid?

A. One atom of nitrogen to three of oxygen; in volumes, one of nitrogen to one and a half of oxygen.

NITRIC ACID (AQUA FORTIS.)

Q. How is nitric acid usually procured?

A. By the action of sulphuric acid on nitre aided by heat. The nitric acid is displaced by the superior affinity of the sulphuric acid for the potash, and being vapourized by the heat, passes into the receiver, where it condenses into a liquid.

Q. What are the properties of nitric acid?

A. When pure it is a colourless liquid, though usually orange coloured, it destroys organic matter, reacts powerfully on metals, and ignites oil of turpentine, charcoal and phosphorus. Nitric acid forms the base of some of the most fulminating compounds.

Q. What is gunpowder?

A. A mixture of nitre, charcoal and sulphur.

Q. What is the composition of nitric acid?

A. It consists of nitrogen one atom to oxygen five atoms.

Q. How is nitric acid tested?

A. By its power of dissolving gold leaf, when mixed with muriatic acid.

Q. Does nitrogen combine with chlorine and iodine?

A. Yes. There is a chloride and iodide of nitrogen.

Q. How is the chloride of nitrogen obtained?

A. By placing a bell glass filled with chlorine over a solution of nitrate of ammonia, the chloride appears in oleaginous drops, which subside at the bottom of the basin.

Q. How is the iodide of nitrogen obtained?

A. By putting iodine into a solution of ammonia. The alkali is decomposed with formation of idohydric acid and chloride of nitrogen, the latter subsiding in the form of a dark powder.

Q. What are the striking properties of the chloride and iodide of nitrogen?

A. Their very explosive nature.

COMBUSTION.

Q. What is combustion?

A. A state of intense chemical action, accompanied with an evolution of heat and light.

Q. What was Stahl's theory of combustion?

A. That all substances in burning give out a common principle of inflammability, called phlogiston.

Q. Was the Stahlian doctrine objectionable?

A. It was, because metals become heavier during combustion. By the advocates of this doctrine, a metallic oxide was considered as a simple substance, and the metal itself was deemed a compound of its oxide with phlogiston. Carbon was regarded by them as phlogiston nearly pure, and that on burning it became phlogisticated air, the name then given to nitrogen.

Q. What effect had the discovery of oxygen on the phlogistic theory?

A. It proved fatal to it, because its absorption in combustion is the reason that metals become heavier.

Q. Who had the honour of establishing the antiphlogistic theory?

A. Lavoisier: who found that combustion and oxidation in general, consist in the combination of the combustible matter with oxygen. On burning phosphorus in a jar of oxygen, he found that a quantity of the gas disappeared, that the phosphorus gained weight, and that the increase of the latter exactly corresponded to the loss of the former.

Q. Did Lavoisier entertain entirely correct views on the subject?

A. No. He made combustion to consist in the union of oxygen with combustible bodies solely, not providing for exceptions, as when metals enter into combustion with chlorine or sulphur.

Q. To what does the heat and light of combustion appear to be due?

A. The former to the agent, or supporter, the latter to the combustible.

Q. What is the product of the combustion of a combustible body in oxygen gas?

A. Either an ordinary oxide, an acid, or an alkali.

Q. What nomenclature is given to oxides expressive of the degree of oxidizement?

A. A compound of the combustible with one atom of oxygen is called protoxide; with two atoms of oxygen, deutoxide; with three, tritoxide; and the highest degree of oxidizement is denominated peroxide.

Q. What results from burning metals in chlorine, iodine, bromine, &c?

A. Chlorides, iodides, and bromides. The nomenclature of these does not vary from oxides.

ACIDITY.

Q. What properties distinguish acids?

A. They have a sour taste, redden vegetable blues, and restore colours changed by alkalies, and generally are very soluble, and capable of uniting in definite proportion with alkaline bases.

Q. Are all acids sour?

A. Silex being insoluble does not taste sour.

Q. Do all acids redden vegetable blues?

A. No. Sulphurous acid whitens litmus, and indigo is not reddened by any acid.

Q. Is oxygen the sole acidifying principle?

A. It is not. Chlorohydric, sulphydric, and cyanhydric, (prussic acid,) are acids containing no oxygen.

Q. What is the nomenclature expressive of the quantity of oxygen or other acidifying agent in an acid?

A. The name of that acid which contains the most oxygen is made to terminate in *ic*, and that which contains the lesser in *ous;* thus we have sulphuric and sulphurous acids. When the acidifying radical is capable of forming acids with more than two proportions of oxygen, that acid which contains less oxygen than the one ending in ous, is distinguished by having *hypo* prefixed. This word is also applied when the acid contains more oxygen than one ending in ous, but less than that of one ending in ic. An example of the former is furnished by hpyo-sulphurous acid, and of the latter by hypo-sulphuric acid.

Q. What vegetable substance is generally used for testing acids?

A. Litmus, which is changed from blue to red by them.

Q. Is there any body to which the term acidifying principle is strictly applicable?

A. There is not. As oxygen, in combining with substances, forms alkalies as well as acids; it may be deemed a new property peculiar to the compound.

ALKALINITY.

Q, What properties distinguish alkalies?

A. Their peculiar alkaline taste, by producing in certain vegetable substances peculiar changes, neutralizing acids, and restoring colours changed by them; and combining with oils rendering them soluble in water.

Q. Will all alkalies render oils soluble?

A. Some of the alkaline earths do not.

Q. What vegetable substance is the best test for alkalies?

A. A blue infusion obtained from red cabbage; which is rendered green by any alkali.

Q. Are all the alkaline bases metallic oxides?

A. Excepting ammonia and the vegetable alkalies, they are all oxides of metals.

AMMONIA.

Q. In what does ammonia exist?

A. Excepting the alkaline vegetables, with a few others, its existence is exclusively in animal matter.

Q. What is ammonia?

A. It is a gaseous compound, of one equivalent of nitrogen to three of hydrogen.

Q. How is ammonia procured?

A. By heating together slacked lime and muriate of ammonia. The muriatic acid unites with the lime, and the ammonia escapes.

Q. What are the properties of ammonia?

A. It is a colourless gas, irrespirable, not inflammable in the air, yet explodes with chlorine, in consequence of the affinity of the latter for hydrogen, and is very absorbable by water. In consequence of its powerful alkaline properties, and volatile nature, it is called the volatile alkali.

Q. How is liquid ammonia obtained?

A. By passing the gas into water.

Q. What are the properties of liquid ammonia?

A. It is a colourless liquid, of a caustic acrid taste, and peculiar pungent smell. When concentrated it blisters the tongue and skin, boils at 150°, is very attractive for carbonic acid, and capable of dissolving resins and many vegetable substances. It is incompatible with all acids, and most of the earthy and metallic salts. The best antidote for the poisonous effects of ammonia is vinegar, which forms with it the acetate of ammonia.

Q. What are some of the salts of ammonia?

A. The sulphate, muriate, and carbonates. The carbonate is generally known as the salt of ammonia.

Q. What is the old name for ammonia?

A. Hartshorn, derived from the circumstance of obtaining it from the horn of the hart.

Q. How is the muriate of ammonia obtained?

A. By the destructive distillation of animal matter we obtain ammonia, water, carbonic acid, and empyreumatic oil, which results in impure subcarbonate of ammonia, water, &c. Then by the double decomposition between common salt and the sulphate of ammonia, which is formed by saturating the products with sulphuric acid, muriate of ammonia and sulphate of soda is obtained.

Q. How is the common carbonate procured?

A. By heating a mixture of muriate of ammonia and carbonate of lime. It is a subcarbonate.

Q. What effect has the air on this salt if exposed for a time to it?

A. Ammonia is volatilized in a sufficient quantity to convert it into a bicarbonate.

Q. What is the composition of ammonia in volumes?

A. Of one volume of nitrogen to three of hydrogen, resulting in four volumes, which are condensed into two.

Q. Can ammonia be resolved into a metallic base?

A. Some chemists have inferred the existence of such a principle, called ammonium.

PHOSPHORUS.

Q. From what may phosphorus be obtained?

A. Phosphate of lime in bones, or phosphate of soda in urine.

Q. How is it procured?

A. By subjecting bones to heat, in order to destroy the animal matter existing in them, we have left phosphate of lime. The phosphate of lime thus obtained is decomposed by the action of sulphuric acid into sulphate of lime, and superphosphate of lime. On the addition of boiling water the superphosphate is dissolved, and may be separated by filtration; evaporate this to the consistence of a syrup, and then ignite it in a retort with charcoal, the beak of which is allowed to enter some water. The phosphorus distils into the water in tears. From phosphate of soda phosphorus may be obtained by complex affinity with nitrate of lead. Phosphate of lead is formed, which yields phosphorus by distillation with charcoal.

Q. What are the properties of phosphorus?

A. It is a flexible, colourless, or flesh coloured, translucent solid, susceptible of a slow and quick combustion; inflames at the temperature of 119°, boils at 550°, of the odour of garlic, insipid, and insoluble in water. Equivalent number 12.

Q. What are the compounds of phosphorus and oxygen?

A. An oxide of phosphorus, phosphoric, phosporous, and hypophosphorous acids.

Q. What is the composition of this oxide?

A. Three atoms of phosphorus with one of oxygen.

Q. What is the composition of hypophosphorus acid?

A. Two atoms of phosphorus with one atom of oxygen.

Q. How is phosphorus acid obtained?

A. By passing vapourized phosphorus over corrosive sublimate heated in a tube, chloride of phosphorus results, which, by the decomposition of water, forms muriatic and phosphorus acids. The former, being most volatile, may be separated by heat.

Q. What are the properties of phosphorous acid?

A. It is a colourless solid, strong taste and smell, and susceptible of volatilization.

Q. What is the composition of this substance?

A. Two atoms of phosphorus with three atoms of oxygen.

Q. How is phosphoric acid obtained?

A. By the ordinary combustion of phosphorus in the air, or oxygen, or by the decomposition of bones. Commonly procured by adding phosphorus gradually to nitric acid heated.

Q. What are the properties of phosphoric acid?

A. It is a solid, unalterable by heat, strong taste, inodorous, and soluble in water.

Q. What is the composition of phosphoric acid?

A. Two atoms of phosphorus with five atoms of oxygen.

Q. What is formed when this acid is exposed to a red heat, and afterwards cooled?

A. *Paraphosphoric acid*, which is a transparent, brittle glass. Nitrate of silver yields with phosphoric acid a yellow precipitate; with paraphosphoric acid a white one.

Q. What is the acid contained in fused phosphate of soda considered to be?

A. A third species, called *pyrophosphoric acid.* These all agree in composition, but not in properties, and hence they are termed *isomeric* bodies.

Q. With what other substances does phosphorus combine?

A. With chlorine, bromine, iodine, sulphur, selenium and hydrogen.

Q. What is formed by phosphorus with hydrogen?

A. Protophosphoretted hydrogen and perphosphoretted hydrogen.

Q. How is protophosphoretted hydrogen obtained?

A. By adding some phosphorus to the materials for generating hydrogen. Or, after filling a small retort with a solution of caustic potash, displace about two-thirds of the solution by introducing hydrogen gas. Then introduce a given quantity of phosphorus, and apply heat. Water is decomposed by the alkali, and phosphate of potash is formed by the union of phosphorus, oxygen and potash. The hydrogen of the water dissolves a portion of the phosphorus, which is spontaneously inflammable, so that it explodes as it escapes, and forms a succession of beautiful rings of smoke. Protophosphoretted hydrogen may also be obtained by the action of phosphide of lime on water.

Q. What are the properties of this substance?

A. It is an inflammable gas, with a garlic smell, and, on meeting with oxygen, becomes luminous in the dark.

Q. What is the composition of this gas?

A. It consists of phosphorus and oxygen, each one atom.

Q. How is perphosphoretted hydrogen obtained?

A. By heating, in a retort, phosphorus, slacked lime and water.

Q. What are the properties of perphosphoretted hydrogen?

A. It is a colourless gas, with a garlic smell, bitter taste, smokes exposed in the air.

CARBON.

Q. What is a specimen of pure carbon?

A. The diamond.

Q. In what is carbon found to exist?

A. The various kinds of coal, as the anthracite and bituminous coal, as an essential element in animal and vegetable matter, and is especially a constituent of the fibres of wood.

Q. How is it obtained?

A. By burning wood with a smothered flame, in a limited access of air. The heat drives off all the oxygen and hydrogen, and nothing is left but charcoal.

Q. Can you give the properties of carbon?

A. Charcoal is black, insipid, inodorous, next to metals the best conductor of electricity, one of the best radiators and worst conductors of heat, and absorbs moisture.

Q. To what cause is attributed its nonconducting power?

A. Its porosity, as in the form of anthracite; carbon conducts heat better.

Q. What is the hardest and most brittle substance known?

A. Crystallized carbon, or diamond.

Q. How is the identity of carbon and the diamond proved?

A. When equal weights of charcoal and diamond are severally exposed to the rays of a powerful lens, in oxygen gas

included in different bell glasses, they are both converted into carbonic acid. The equivalent weight of carbon is represented by 6.

Q. With what does carbon combine?

A. Oxygen, hydrogen, nitrogen, sulphur, and chlorine.

Q. Can you enumerate the compounds of oxygen and carbon?

A. Carbonic oxide, carbonous, and carbonic acid.

Q. How is carbonic oxide procured?

A. By heating chalk with iron filings in a gun barrel at a white heat. The carbonic acid of the carbonate is liberated, part of the oxygen of which is detained by the iron.

Q. What are the properties of carbonic oxide?

A. It is a deleterious gas, irrespirable, and does not support combustion.

Q. What is its composition?

A. Carbon and oxygen, each one atom.

CARBONIC ACID.

Q. Where does carbonic acid exist?

A. In the atmosphere in a very small proportion, and is a product of combustion, and of the respiration of animals. It is a principal ingredient in marble and limestone, existing in the state of carbonate.

Q. How is carbonie acid procured?

A. By the action of an acid, or heat, on any carbonate. Usually by the superior affinity of sulphuric acid for the lime in marble. It is also produced by the combustion of charcoal, and is evolved during the vinous fermentation.

Q. What are the properties of carbonic acid?

A. It is a colourless gas, rendered liquid by great pressure,

irrespirable, extinguishes flame, and absorbable by an equal bulk of water. It is a heavy gas, specific gravity being 1.52.

Q. What does it form insoluble compounds with?

A. Lime, barytes, and oxide of lead; consequently these form good tests for it.

Q. Does it possess good medical qualities?

A. Yes. It is antiseptic, and in water grateful to the stomaeh.

Q. What is the common mineral water of the shops?

A. Water impregnated with carbonic acid.

Q. What is considered the best test for earbonic aeid?

A. Lime; on the water of which it forms a pellielc of carbonate of lime.

Q. What is the composition of earbonie acid?

A. One atom of earbon to two atoms of oxygen.

OXALIC ACID.

Q. What is oxalic, or carbonous acid?

A. It is a vegetable acid, in the state of a erystalline solid, possessing poisonous properties.

Q, What is its composition?

A. It eonsists of carbonic oxide with earbonie acid, each one atom, with water. Its solid state is owing to the water whieh enters its composition.

Q. How is this composition proved?

A. By the affinity of sulphuric acid for water, the two gases may be separated. With lime water the carbonate acid may be removed from the earbonie oxide.

Q. How is oxalie aeid obtained.

A. By the action of nitric acid on sugar. It may also be procured from starch, molasses, common sorrel, wood sorrel, &c.

Q. From what does it derive its name?

A. *Oxalis acetosella*, in which it exists in the state of binoxalate of potash.

Q. Give the properties of oxalic acid?

A. It is a solid, having a sour taste, soluble in water and alcohol—with chlorodydric acid forms a crystalline compound, called *chloroxalic acid*, and it is an energetic poison.

Q. What is the best antidote?

A. Magnesia and chalk.

Q. What are other compounds of carbon with oxygen?

A. Mellitic and croconic acids.

Q. What is the best test for oxalic acid?

A. Lime, with which it forms an insoluble oxolate.

Q. What is the ultimate composition of oxalic acid?

A. Two atoms of oxygen with three atoms of carbon.

Q. What is formed by the union of carbon with hydrogen?

A. Light carburetted hydrogen (fire damp) and deutocarbohydrogen, or olefiant gas.

Q. Enumerate the two groups of compounds of carbon with hydrogen?

A. In the first there are four, viz: light carburetted hydrogen, carbohydrogen, bicarburet of hydrogen and naphthaline. In the second there are five, namely, protocarbohydrogen, deutocarbohydrogen, tritocarbohydrogen, tetartocarbohydrogen and hexacarbohydrogen.

LIGHT CARBURETTED HYDROGEN.

Q. By what names is this substance distinguished?

A. Inflammable air, carburetted hydrogen (fire damp) and bihydroguret of carbon.

Q. How is it procured?

A. From the mud of stagnant water, from which it is liberated, and collected by means of inverted bottles.

Q. What are the properties and composition of this gas?

A. It is colourless, irrespirable, and having more than a negative influence in destroying life. Composed of two volumes or atoms of hydrogen, with one volume or atom of carbon, condensed into one volume.

DEUTOCARBOHYDROGEN, OR OLEFIANT GAS.

Q. How is olefiant gas obtained?

A. By distilling alcohol with sulphuric acid. The acid unites with the water of the alcohol, and leaves the gas.

Q. Give the properties and composition of this gas?

A. It is invisible, elastic, when inhaled produces asphyxia, burns with splendour, and detonates violently with oxygen. Composed of carbon vapour and hydrogen, each one atom, and in volumes, one of each condensed into half a volume.

Q. What is a solid compound of hydrogen and carbon?

A. A crystalline substance obtained by the distillation of tar from the neck of the retort where it crystallizes. It is called naphthaline, has an aromatic smell, and a pungent disagreeable taste.

Q. From what substances in general may the compounds of carbon and hydrogen be obtained?

A. By the distillation of bituminous coal, wood, oil, tar, and other inflammable substances.

Q. What general properties distinguish these compounds?

A. Their inflammability and volatility. They do not support combustion, and, in the vaporous or liquid form, are highly stimulating. In the gaseous state they constitute the flame of candles, lamps, gas lights, and culinary fires.

Q. On what depends the illuminating power of these gases?

A. The proportion or quantity of carbon condensed into a volume, provided there be enough oxygen to consume it. If carbon be in excess the flame is rendered smoky.

CYANOGEN.

Q. What is the most expressive name for cyanogen?

A. Bicarburet of nitrogen.

Q. How is cyanogen obtained?

A. By distilling the bi-cyanide of mercury.

Q. What are the properties of cyanogen?

A. It is a gas, irrespirable, colourless, rendered liquid by pressure, absorbable by water, and still more by alcohol; and is characterized by burning with a beautiful violet flame. In relation to the galvanic poles it is electro-negative.

Q. What happens when it is detonated with a quantity of oxygen?

A. It is converted into two volumes of carbonic acid and one of nitrogen.

Q. What is the composition of cyanogen?

A. In consists of two volumes of carbon vapour and one of nitrogen, condensed into one volume.

Q. What does cyanogen form with hydrogen?

A. Cyanhydric or prussic acid.

Q. How is prussic acid procured?

A. By the distillation of bi-cyanide of mercury with muriatic acid. The acid is decomposed, the chlorine unites with the mercury, forming bi-chloride, and the hydrogen and cyanogen pass over as prussic acid.

Q. How is prussic acid made of sufficient strength for medical purposes?

A. Add one pound of muriatic acid, diluted with six pints of water, to a pound of the bi-cyanide; after which bring over six pints. Another mode of obtaining the strongest hydrocyanic acid, is by exposing crystals of bi-cyanide of mercury in a tube to sulphretted hydrogen, and condense the vapours in a receiver surrounded by salt and snow.

Q. What are the properties of cyanhydric or prussic acid?

A. It is a colourless liquid, the most volatile substance known; freezing by its own evaporation; of a cooling taste, and is deadly poisonous.

Q. What is the composition of this acid?

A. It consists of cyanogen and hydrogen, each one volume and each one atom.

Q. Does cyanogen combine with any thing but hydrogen?

A. Yes; with oxygen, forming cyanic acid; with chlorine, forming chlorocyanic acid. The acid called fulminic, in fulminating mercury and silver, is ascertained to be identical with cyanic acid. Cyanogen also unites with sulphur.

Q. Does sulphur and carbon form a compound?

A. Yes; a bi-sulphide of carbon.

Q. How obtained?

A. By passing sulphur in vapour over ignited charcoal.

BORON.

Q. Where is Boron?

A. It exists in a salt called borax.

Q. How is it obtained?

A. By the reaction of boracic acid with potassium, aided by heat.

Q. What are the properties of boron?

A. It is a dark olive coloured solid, insipid, inodorous, a non conductor of electricity, and insoluble in water, alcohol, æther, or the oils. It is fixed and infusible.

Q. What does it form with oxygen?

A. Boracic or boric acid?

Q. How is boric or boracic acid procured?

A. By adding sulphuric acid to a saturated solution of borax in water, boracic acid is precipitated in fine crystalline plates.

Q. What is borax?

A. Bi-borate of soda.

SILICON.

Q. In what does silicon exist?

A. In silex.

Q. How is silicon procured?

A. By heating potassium in a gas obtained by the action of sulphuric acid on fluoride of calcium and quartz.

Q. What are the properties of silicon?

A. It is of a dark nut brown colour, a non conductor of electricity, infusible, incombustible, and soluble only in a mixture of nitric and fluoric acids.

Q. What is formed by the union of fluorine and silicon?

A. Fluo-silicic acid gas.

Q. What does silicon form with oxygen?

A. Silex, or silicic acid.

Q. Where does silex exist?

A. It constitutes the earth of flints, of sand, and other stony matter. Rock crystal is a specimen of nearly pure silex.

Q. How is silex procured?

A. By fusing powdered quartz with three times its weight of pearl ash, a glass is obtained, which being soluble, forms

with water a liquid called liquor of flints. By means of an acid silex is precipitated from this solution.

Q. What are the properties of silex?

A. It is a solid, of a white colour, insipid, inodorous, and unlike other acids, insoluble. It has never been volatilized.

Q. What is glass?

A. Silicate of potash. Prince Rupert's drops are formed by glass in a state of fusion, being dropped into water.

Q. What is Derbyshire or fluor spar?

A. Fluoride of calcium.

Q. What is formed by the union of fluorine and hydrogen?

A. Fluohydric acid.

Q. How is it procured?

A. By the action of sulphuric acid on fluoride of calcium, in a leaden retort.

Q. What are the most striking properties of fluoric acid?

A. Its volatility, and power of corroding glass.

Q. What is formed when we add to the above material some powdered glass?

A. Fluosilicic acid gas, or fluoride of silicon.

Q. What are the striking properties of this gas?

A. It is permanent over mercury, fumes similar to muriatic acid, though differing from the latter in not being so completely absorbed by water.

Q. What is formed by distilling fluoride of calcium in powders with dry boracic acid?

A. Fluoride of boron, or fluo-boric acid.

Q. What is zirconion?

A. A black powder, which is a nonconductor of electricity.

Q. What is nitro-muriatic acid?

A. A mixture of nitric acid and muriatic acid.

Q. What is the most striking and useful property of this mixture?

A. That of dissolving gold; hence called aqua regia.

Q. To what is its efficiency as a solvent due?

A. The evolution of chlorine.

Q. How do you explain the cause of the evolution of chlorine?

A. The hydrogen of the muriatic acid, and part of the oxygen unite to form water; while chlorine with nitrous acid is evolved.

Q. What are the salts produced by nitro-muriatic acid?

A. Either chlorides or muriates.

METALLIC RADICALS.

Q. What properties distinguish the metals?

A. Their peculiar lustre, when cut, and property of conducting electricity and caloric. They are the worst radiators and best reflectors of heat.

Q. In what respect do the metals differ among themselves?

A. In permanency of lustre, malleability, ductility, elasticity, tenacity, weight, and their chemical affinities.

Q. What metals are remarkable for their permanent lustre?

A. Gold, silver, platinum and palladium.

Q. What metals are most malleable?

A. Gold, silver, copper, tin, platinum, &c. Of these, iron and platinum only can be advantageously hammered at high temperatures.

Q. What are the most elastic metals?

A. Silver, copper, but most of all iron, in the state of steel.

Q. What metals most ductile?

A. Gold, iron, silver, copper, and, in large pipes, lead and tin.

Q. What are the magnetic metals?

A. Nickel, iron and cobalt.

Q. Which are the most tenacious?

A. Iron, copper and platinum.

Q. What are the heaviest metals?

A. Gold, tungston, and the heaviest of all is platinum.

Q. Are all metals solid?

A. No. Mercury is a liquid at ordinary temperatures.

Q. With what do metals combine?

A. Oxygen, chlorine, iodine, bromine, fluorine, sulphur, phosphorus, cyanogen, carbon, and with each other.

Q. How are metals oxidized?

A. Either by heat, deflagration, or the action of acids, or by exposure to the air with or without moisture. Thenard founded his division of the metals on their habitudes with oxygen.

Q. What metals are oxidized by mere exposure to the air?

A. Potassium and sodium.

Q. What metals require heat or moisture for oxidizement?

A. Iron, zinc, tin and manganese. Copper, bismuth, lead, nickel, antimony, arsenic, chromium, and others of this class, do not decompose water, either with or without heat. Mercury can be oxidized at a low temperature, but is incapable of decomposing water.

Q. What metals are there that cannot be oxidized either by heat alone, or with moisture?

A. Gold, silver, platinum, palladium, &c.

Q. What are the peculiarities of metallic oxides?

A. Their capability of forming with acids, salts, and of uniting with one another. They are mostly insoluble in water.

Q. Do metallic oxides form the bases of every salt?

A. No. Salts of ammonia furnish an exception to the rule.

Q. Can salts be formed by the union of metallic oxides?

A. Yes. Some of them having acid properties, form salts by their union with others that are alkaline. Metals are divided according as their oxides pass either of these properties into basefiable and acidifiable metals. The former are subdivided into those that form ordinary oxides and alkalies.

Q. What metals are alkaline?

A. Potassium, sodium, lithium, barium, strontian, calcium and magnesium.

Q. Can you enumerate some of the metals which form ordinary oxides?

A. Iron, zinc, lead, tin, copper, bismuth, mercury, silver, gold, platinum, manganese, and cobalt, are the most important.

Q. Can you enumerate some of the acidifiable metals?

A. Antimony, arsenic, and chromium, are the most important.

Q. How are metals reduced from their oxides?

A. Either by heat alone, or in union with combustible matter, by the galvanic battery, and by means of deoxidizing agents, on metallic solutions.

Q. What do hydrogen and carbon form with metals?

A. Hydrogurets and carburets. The hydrogurets are those of zinc, arsenic, and potassium; and the only carburets are those of iron.

Q. What is an alloy?

A. It is a compound of two metals.

Q. What is an amalgum?

A. It is an alloy with mercury.

Q. Do metals combine with each other in the solid state?

A. No. Attraction of cohesion, which necessarily counteracts chemical affinity, must be subdued before union takes place.

Q. Do metals unite with one another in many or few proportions?

A. Precisely like sulphuric acid and water, when mixed together, they combine in every proportion.

Q. What is understood by the term perfect metals?

A. They are those which, like gold, silver, platinum, possess malleability, ductility, and are not tarnished by exposure to the air, nor oxidized by the heat of the forge.

Q. What specific gravity is considered as essential for metals generally?

A. Excepting those of the alkalies and earths they are over five. Consequently these are called metals proper. The term metalloid is applied to the metallic radicals of the earths and alkalies.

METALS OF THE EARTHS.

Q. What are the metals of the earths proper?

A. Aluminium, glucinium, yttrium, and thorium.

Q. How can aluminium be obtained?

A. By the decomposition of chloride of aluminium, with potassium aided by heat. The chloride is made by transmitting chlorine over alumina and charcoal heated to redness.

Q. Where is alumina, or oxide of aluminium found?

A. In a gem called oriental, in clay, and in alum. Also found as native hydrate in the form of stalactite in quartz.

Q. How is alumina obtained?

A. It is precipitated from a solution of alum by means of an alkali.

Q. What are the properties of alumina?

A. It is white, soft, insipid, inodorous, very infusible, and soluble in water.

Q. What is alum?

A. Sulphate of alumina and potash.

Q. Where is alum found?

A. It occurs native in volcanic countries, and it is largely manufactured in the United States from an ore which contains clay, sulphide of iron, sand, &c., by the aid of sulphate of potash.

ALKALINE EARTHS.

Q. What are the metals of the alkaline earths?

A. Magnesium, calcium, barium, and strontium.

Q. How have these metals been obtained from their oxides?

A. By galvanic means. More recently magnesium has been obtained by heating chloride of magnesium with potassium.

Q. In what states do alkaline earths mostly occur?

A. As carbonates and sulphates.

Q. What properties, as a class, do the alkaline earths possess?

A. They are very fixed and infusible, very sparingly soluble, but more so in cold than in boiling water, very attractive for carbonic acid, and combine with water forming hydrates. The alkaline earths are most soluble in water saturated with carbonic acid, which accounts for their existing in nature as carbonates. As a class, carbonic acid is a good test for them, which forms a pellicle on their solutions.

Q. Where is magnesia found to exist?

A. In sea water, and from a mineral called magnesite.

Q. How can it be procured?

A. By precipitating it from a solution of epsom salt by means of an alkali, in consequence of the superior affinity of

sulphuric acid for the latter, or by depriving the carbonate of magnesia of carbonic acid by the aid of heat.

Q. What are the peculiar properties of magnesia?

A. Its white and friable appearance, nearly tasteless and inodorous, its less energetic affinities and alkaline properties, its insolubility in water, and very ready solubility of its sulphate.

Q. How is lime found to exist?

A. In marble, limestone, and oyster shells in the state of carbonate. Lime is also found as a native sulphate, called plaster of Paris.

Q. How is lime obtained?

A. By expelling water and carbonic acid from limestone by heat.

Q. What are the distinguishing properties of lime?

A. It is of a light gray colour, of an acrid, caustic taste, absorbs water and carbonic acid from the air, becoming white; with the former it becomes a hydrate, and it is slightly soluble.

Q. What phenomenon attends the slacking of lime?

A. The caloric which exists in the water, as the cause of its fluidity, is evolved.

Q. How much lime will water hold in solution?

A. About one-seven hundredths of its weight, forming lime water.

Q. What forms a pellicle on lime water exposed to the air?

A. Carbonate of lime, which results from the affinity of the carbonic acid of the air for the lime.

Q. What is the best test for lime?

A. Oxalic acid, forming an insoluble oxalate of lime.

Q. What is the chemical name for lime?

A. Protoxide of calcium.

Q. What is baryta or barytes?

A. The oxide of barium.

Q. How is baryta obtained ?

A. By dissolving the native carbonate in nitric acid, filtering the solution, evaporating, and then, by heat, driving off the acid.

Q. What are the properties of baryta ?

A. It is of a dark gray colour, absorbs water, and becomes light, like lime in its properties, but more acrid and caustic, and is a poison. It is distinguished from other alkaline earths by the insolubility of its sulphate and superior weight. Its specific gravity is 4.

Q. What is the best test for baryta ?

A. Sulphuric acid, which forms the insoluble sulphate.

Q. How is strontia or protoxide of strontium obtained ?

A. From its carbonate or sulphate exactly as baryta is from its carbonate.

Q. What properties distinguish it from barytes ?

A. By its being less soluble, but more so in boiling than cold water, its crystallization, and not being poisonous.

Q. What is the test ?

A. The red colour, which its solutions give to flame.

METALS OF THE PROPER ALKALIES.

Q. What are the metals of the alkalies proper ?

A. Potassium, sodium, and lithium.

Q. By whom was potassium and sodium discovered ?

A. In the year 1807, Sir Humphrey Davy obtained them, by exposing their oxides, potash and soda, to the divellent influence of the Voltaic poles. Subsequently they were obtained by subjecting these alkalies, in contact with iron, in a divided state, to intense heat in a gun barrel. More recently they

have been reduced by heating caustic potash or soda with iron filings.

Q. What are the properties of potassium ?

A. It is white like silver, melts in the air, very attractive for oxygen, and takes fire on water, forming a potashuret of hydrogen, which is spontaneously inflammable. The equivalent number of potassium is 40 and specific gravity 0.865.

Q. What are the peculiar properties of sodium ?

A. Its burning on water without flame, attended with an effervescence and a hissing noise. It is of a bright lustre, tarnishes on exposure to the air, though less rapidly than potassium. Its equivalent number is 24, and specific gravity 0.972.

Q. What is potash and soda chemically speaking ?

A. Oxides of potassium and sodium.

Q. How do they exist in nature ?

A. As sulphates, nitrates, and muriates, but principally in the state of carbonates.

Q. Where do the carbonates of potash and soda exist ?

A. The former in the ashes of inland plants, the latter in kelp and barilla, or ashes of sea plants generally.

Q. What are properties common to potash (potassa) and soda ?

A. They are solids of a grayish white colour, difficult of fusion, caustic, and have so strong an affinity for water, with which they form hydrates, that they cannot exist in an atmosphere which contains moisture. In consequence of their powerful alkaline properties, they are called the fixed alkalies.

Q. What properties distinguish the fixed alkalies from each other ?

A. Potash is the most active and deliquescent, soda effloresces; potash is more soluble than soda, yet the salts of soda are more soluble than those of potash. Potash may also be distinguished from soda, by forming a less soluble salt with tar-

taric acid, (the bi-tartrate of potash,) and from all other substances, by giving a yellow coloured precipitate with muriate of platinum, which is named chloroplatinate of potash.

Q. What are formed when potassium burns in the air, or sodium on water?

A. Orange coloured peroxides of these metals.

Q. What is caustic potash, or soda?

A. Hydrates of these alkalies.

Q. How is caustic potash obtained?

A. By means of the double decomposition which ensues between hydrate of lime (slacked lime) and impure carbonate of potash (pearl ash) when they are boiled together. Evaporate the solution to dryness, and fuse it into moulds. By dissolving in alcohol, caustic potash thus obtained may be freed from iron and other impurities.

Q. What are the important salts of potash?

A. The carbonates, muriate, nitrate, sulphate, and tartrates.

Q. What is the potash of commerce?

A. It is a very impure carbonate, containing silex, with salts, and is of a variegated appearance.

Q. How are the potashes of commerce procured?

A. By boiling down the ley obtained by lixiviating the ashes of wood or inland plants.

Q. How is pearlash procured?

A. By subjecting the potashes to intense ignition, lixiviation, and evaporation to dryness. It is called pearlash, on account of its pearly white colour.

Q. How may the purest carbonate be obtained?

A. By subjecting pearlash to an intense heat, triturating with water, and evaporating the decanted solution to dryness.

Q. What are some of the salts of soda?

A. The carbonate, sulphate, (Glauber's salt,) and muriate, (common salt,) and phosphate.

Q. What are tests for soda?

A. The solubility of all its salts, and power of communicating to the blowpipe flame, by means of platinum wire, a rich yellow colour.

Q. What alkali was discovered in 1818?

A. Lithia, which is found to exist in a mineral called petalite.

Q. What are the peculiar properties of lithia?

A. Its great neutralizing power, its forming sparingly soluble salts with carbonic and phosphoric acids, and soluble salts with sulphuric and oxalic acids; and all its salts tinge the flame of the blowpipe red.

Q. What results from the reaction of chlorine with the metals of the earths and alkalies?

A. When the oxides of calcium, barium, strontium, potassium, sodium and lithium are treated in chlorine, these metals are converted into chlorides, and the oxygen is expelled.

Q. What are the properties of these chlorides?

A. They are generally solid, soluble in water, and, in solution, precipitate silver, lead and black oxide of mercury.

Q. What chlorides are liquids?

A. The bichlorides of tin and arsenic.

Q. Are all chlorides soluble?

A. No. Chloride of silver and protochloride of mercury are insoluble.

Q. What are dissolved chlorides considered to be?

A. Chlorohydrates or muriates. The conversion of chlorine into muriatic acid is effected by the decomposition of water, which furnishes hydrogen to the chlorine.

Q. What muriate is decomposed by heat?

A. Muriate of magnesia.

Q. How are bromides and iodides obtained?

A. Like chlorine, bromine and iodine unite with metallic

substances, by displacing oxygen from their oxides. Iodine is capable of expelling oxygen only from potash, soda, oxides of lead and bismuth.

Q. When combined with water, what are bromides and iodides considered to be?

A. Bromohydrates and idohydrates.

Q. How are bromides and iodides distinguished?

A. Bromides emit red vapour, when heated in a tube with the bisulphate of potash, and do not deflagrate when thrown on incandescent coals. Iodides, when subjected to a small quantity of sulphuric acid in a tube, will give off a violet vapour; a blue colour is produced when mingled with starch, and is displaced from its combinations by chlorine.

Q. What happens when potassium and sodium are heated in cyanogen?

A. A cyanide is produced. Cyanide of potassium is procured by igniting potash in contact with animal matter. Cyanogen is generated by the union of carbon and nitrogen, which combining with potassium forms the cyanide.

Q. How are cyanides detected?

A. By their producing a blue colour with solutions of the peroxide of iron; also, by giving the odour of peach blossoms, when subjected to chlorohydric acid.

Q. How can sulphides (sulphurets) be formed?

A. Either by heating sulphur with a metal or metallic oxide; by depriving a sulphate of oxygen, by means of heat and combustible matter; or by passing sulphydric acid gas into a metallic solution. Sulphides of lead, antimony, copper, iron, zinc and silver occur in nature.

Q. What properties distinguished the sulphides?

A. They are solid, brittle, and, excepting those of the alkalies and earths, are all insoluble in water. The alkaline sul-

phides, on being moistened with water, evolve sulphydric acid, and still more by being subjected to chlorohydric acid.

Q. How distinguish selenides?

A. When heated they produce the smell of horse-radish.

METALS PROPER.

GOLD.

Q. In what state does gold occur in nature?

A. Either pure, or alloyed with silver or copper.

Q. Where are gold mines found?

A. In Transylvania, South America, and in the United States.

Q. How is gold obtained from its impurities?

A. By the process of amalgamation and distilling off the mercury. Pure gold may be obtained by precipitating it from a solution of the coin in nitro muriatic acid, by means of proto-sulphate of iron.

Q. Can you give the properties of gold?

A. It is of a yellow colour, the most malleable and ductile of all the metals, possesses but little affinity for oxygen or sulphur, and its specific gravity is 19.3.

Q. What is the proper solvent?

A. Chlorine is the only solvent of gold. The efficacy of nitro-muriatic acid as a solvent of gold, is owing to the evolution of chlorine.

Q. Can you enumerate some of the compounds formed with gold?

A. There are two oxides, two chlorides, and a sulphide. Gold combines with nearly all the metals, and energetically with mercury.

Q. What is the best test for gold?

A. Proto-muriate of tin, which furnishes a purple precipitate which is a compound of peroxide of tin and oxide of gold.

Q. What is fulminating gold?

A. The aurate of ammonia.

PLATINUM.

Q. What is the origin of platinum?

A. It is found in South America in native metallic grains, either alone or associated with other metals.

Q. How is the solid metal obtained?

A. By dissolving the native grains in nitro-muriatic acid, and precipitating the solution by means of muriate of ammonia. This precipitate, which is the ammoniacal muriate of platinum is then to be exposed to intense ignition, which developes the metal in a divided state. The minute particles thus obtained are subjected to intense pressure, by which they are made to cohere.

Q. Can you give the properties of platinum?

A. It is white like silver, though inferior in lustre, malleable and ductile, very infusible, soluble in nitro-muriatic acid, and the heaviest metal. Specific gravity $21\frac{1}{2}$.

Q. Are there any compounds with platinum?

A. There are two or more oxides, two chlorides and a sulphide.

Q. What are precipitants of platinum?

A. Ammonia, and a solution of a salt of potash forms with the muriate a yellow precipitate. The former produces muriate

of platinum and ammonia; the latter, what is called chloroplatinate of potash.

Q. What is the best test for platinum?

A. Protomuriate of tin, which produces a claret coloured precipitate.

Q. What other metals are frequently found in company with the native grains of platinum?

A. Osmium, palladium, rhodium and iridium.

SILVER.

Q. In what states does silver occur in nature?

A. Metallic, nearly pure, and as a sulphide, chloride, iodide and carbonate; but most abundant is the argentiferous galena. Silver is likewise alloyed with gold and other metals.

Q. Where are silver mines found?

A. In Mexico, Peru, Norway, Hungary and Transylvania. No mines in the United States, but it is found as argentiferous galena in several localities.

Q How is metallic silver extracted from its ores?

A. By the processes of amalgamation and cupellation. Pure silver may be obtained by dissolving the coin in nitric acid, and evaporating by heat.

Q. What are the properties of silver?

A. It is of a white colour, brilliant, very malleable and ductile, very tenacious, fusible at a red heat, insusceptible of oxidizement in the air, possesses a strong affinity for sulphur and chlorine, the former of which tarnishes it, is one of the best conductors of heat, and its specific gravity 10.5.

Q. How many oxides of silver are there?

A. Two: a protoxide and peroxide.

Q. What is the proper solvent of silver?

A. Nitric acid, a part of which oxidizes the metal, and the oxide thus formed is dissolved by the other part forming nitrate of silver in solution.

Q. What is lunar caustic?

A. Fused nitrate of silver.

Q. Does sulphuric acid react with silver?

A. Only at a boiling heat, by which a sulphate is formed.

Q. Is silver soluble in nitromuriatic acid?

A. No; because an insoluble chloride would be formed.

Q. What is the best test for silver?

A. Chlorine; forming an insoluble chloride; consequently, the muriates form good tests for silver.

Q. What are the properties of the chloride?

A. Precipitated it is white, insoluble in water, sparingly soluble in acids, but is soluble in ammonia, decomposed by hydrogen when evolved in contact with it, and by fusion with tin, zinc, or the fixed alkalies, or when boiled in water with pieces of iron.

Q. What are the precipitants of silver?

A. Muriates, phosphates, chromates, arsenites, arseniates, copper and mercury.

Q. What is fulminating silver?

A. Cyanide of silver, formed by mixing the metal with cyanhydric acid.

MERCURY.

Q. How does mercury occur in nature?

A. In its metallic state, either alone or amalgamated with silver, and as an oxide, chloride and sulphide. The sulphide known in commerce as the native cinnabar, is the most abundant ore of mercury.

Q. Where is mercury found to exist?

A. In Spain, Hungary, Asia and South America.

Q. How is metallic mercury procured?

A. By distilling native cinnabar with iron filings or lime, which detain the sulphur.

Q. What are the properties of mercury?

A. It is of a silver white colour, its freezing point is at 39° below zero, its boiling point is at 656°, it slightly tarnishes in the air, and it is the only metal that is liquid at the ordinary temperatures of the atmosphere. Its specific gravity is 13.6, and its atomic weight is represented by 200.

Q. How many oxides of mercury are there?

A. Two; a protoxide and deutoxide.

Q. How may the protoxide be formed?

A. By exposing mercury to mechanical agitation in the air, or by mixing calomel briskly with pure potassa in excess, and washing with water. This oxide is also obtained by precipitation from a solution of the proto-nitrate of mercury, by means of pure alkalies.

Q. What properties characterise this oxide?

A. It is of a black colour, insoluble; it is medicinal per se, and forms, by union with acids, medicinal salts. It is called, from its black colour, the black oxide of mercury. This oxide enters the composition of the blue mass and the mercurial ointment.

Q. How is the blue mass and mercurial ointment made?

A. The former by rubbing mercury with the conserve of roses, until the globules disappear; the latter by rubbing mercury with lard, in which case only part of the mercury is supposed to be oxidized.

Q. How is the peroxide of mercury formed?

A. Either by calcining mercury in the air, or decomposing

the nitrate by intense heat. This oxide is called, in popular language, red precipitate.

Q. What are the properties of this oxide?

A. It is of a scarlet red colour, slightly soluble in water, forming a solution of an acrid taste. This oxide is poisonous, and forms poisonous salts.

Q. How many sulphides of mercury?

A. Two; a simple and a bisulphide.

Q. How is the simple sulphide formed?

A. By passing sulphydric acid gas through a solution of the protonitrate of mercury. It is of a dense black colour.

Q. How is the bisulphide formed?

A. By fusing sulphur with about six times its weight of mercury. When thus formed, it is the artificial cinnabar. It is of a gray colour, and when levitigated it is converted into vermillion, which is red.

Q. What is Ethiop's mineral?

A. It is a mixture of the bisulphide with sulphur. It is made by triturating together equal weights of mercury and sulphur.

Q. What are the salts of mercury?

A. The nitrates, sulphates, muriates and phosphates.

Q. How is the nitrate formed?

A. By the action of nitric acid on mercury. If the metal be in excess, protonitrate is formed; but if the acid be in excess, the deuto or pernitrate results.

Q. In what respect do these nitrates differ?

A. The crystals of the protonitrate are white; those of the deutonitrate are yellow.

Q. Is there any reaction between cold sulphuric acid and mercury?

A. No; but, when boiled on mercury, the acid is decomposed; one portion yielding oxygen to the metal, while the

other, uniting with the oxide thus formed, results in the sulphate.

Q. How is the protosulphate formed?

A. By heating two parts of mercury with three of sulphuric acid, so as to form a slow effervescence. For medicinal purposes it is made by triturating metallic mercury with the bisulphate of the deutoxide.

Q. Is this salt of interest?

A. Yes; because it is used for making calomel. It is white and insoluble.

Q. How is the bipersulphate of mercury made?

A. According to the Pharmacopœia of the United States, it is prepared by boiling two pounds of mercury with thirty ounces of sulphuric acid, until the mass is dry.

Q. Of what interest is this salt?

A. It is used for making corrosive sublimate. It is a fine white salt, and more soluble than the protosulphate. From this sulphate the United States Dispensatory gets the protosulphate for the purpose of making calomel.

Q. How is the conversion of this salt into the protosulphate explained?

A. When it is triturated with metallic mercury, the metal is oxidized at the expense of one equivalent of its oxygen, with which one equivalent of the sulphuric acid combines to form one equivalent of protosulphate of mercury. Hence one equivalent of the bipersulphate is converted into two equivalents of the neutral protosulphate.

Q. What is formed by throwing the bipersulphate into water?

A. A yellow precipitate, commonly called *turpeth mineral.*

Q. What is turpeth mineral?

A. According to general consent, it is considered to be a persulphate of mercury, that is the neutral sulphate of the peroxide,

usually called the subsulphate. Opinion is not uniform as to the manner in which the formation of turpeth mineral should be explained. This change is generally supposed to consist in the separation, by the action of the water, of one equivalent of sulphuric acid, which remains in the solution; and upon this supposition, the preparation under consideration would be simply a persulphate of mercury, consisting of one equivalent of acid and one equivalent of peroxide of mercury. But it would appear, that the water separates something more than the sulphuric acid, for the solution is found to contain mercury, and when evaporated will yield a white crystalline salt. According to Turner, the hot water retains some of the sulphate in solution, together with free sulphuric acid. Berzelius is of opinion that the bipersulphate is decomposed by the water into supersulphate, which remains in solution, and a subsesquisulphate, which being insoluble precipitates as the turpeth. Another explanation is that given by Dr. Hare, which, while it reconciles the facts, is at the same time more simple and satisfactory. He assumes the dry mass, which yields the turpeth by washing, to be a mixture of bisulphate and neutral-sulphate, and that the former is dissolved while the latter remains in solution.

Q. Is mercury soluble in muriatic acid?

A. No. But the oxide of mercury is soluble in this acid, which results in a chloride of the metal.

Q. What are the chlorides of mercury?

A. There are two; the protochloride or calomel, and the deutochloride, or corrosive sublimate. The former of these are designated as the mild or weak chloride, and the latter as the corrosive chloride of mercury.

Q. How is calomel prepared?

A. There are two modes of obtaining calomel, one by subli-

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mation, which is the dry way, the other by precipitation, or the moist way.

Q. How is calomel made by sublimation ?

A. Either by subliming metallic mercury with corrosive sublimate, or by the reaction between chloride of sodium and the protosulphate of mercury, when they are sublimed together.

Q. What is the process of the United States pharmacopœia ?

A. Boil two pounds of mercury with thirty ounces of sulphuric acid in a glass vessel until the sulphate is left dry. Rub this when cold with two pounds of mercury in an earthenware mortar, so that they be thoroughly mixed; then add chloride of sodium, and rub it with the other ingredients till the globules disappear; afterwards sublime. Reduce the sublimed mass to a very fine powder, pass it through a sieve, and washing it repeatedly in boiling distilled water, till this affords no precipitate upon the addition of water of ammonia.

Q. What is the rationale of the formation of calomel ?

A. If, for the sake of simplicity we take a single equivalent of the reacting materials, it may be thus explained: One equivalent of proto-sulphate of mercury consists of one equivalent of sulphuric acid, one of oxygen, and one of mercury ; and one equivalent of chloride of sodium consists of one equivalent of chlorine, and one equivalent of sodium. The one equivalent of chlorine unites with one equivalent of mercury, and forms one equivalent of calomel which sublimes, while the single equivalent of each, sulphuric acid, oxygen, and sodium, combine together, to form one equivalent of dry sulphate of soda as a residue. Hence, it is essential in order to form calomel, that equal equivalent proportions of the materials should be employed, and that in giving the exact rationale as made by the direction of the United States pharmacopœia, it should be borne in mind, that two equivalents of the protosulphate being present, two equivalents of chloride of sodium

is required, and which forms two equivalents of calomel and two equivalents of dry sulphate of soda.

Q. Why, in this case, do we presume two equivalents of protosulphate to be present?

A. Because one equivalent of bipersulphate is converted into two equivalents of the protosulphate as preliminary, by the United States formula; therefore, it is better for the sake of perspicuity and consistency to assume such a composition.

Q. What are the properties of calomel?

A. It is a white crystallin epowder, compact, tasteless, insoluble, blackened by long exposure to light, and becomes black or brown by trituration with alkalies or lime water.

Q. What are tests of its purity?

A. Its complete sublimation by heat and striking a black colour free from a reddish tinge, by the contact of fixed alkalies.

Q. How is calomel prepared by precipitation?

A. By adding to a solution of protonitrate of mercury, muriate of soda, (common salt.)

Q. How is corrosive sublimate formed?

A. Either by heating mercury in chlorine gas, or by dissolving the deutoxide of mercury in muriatic acid. In the former case chlorine combines directly with mercury; in the latter, the hydrogen of the acid and the oxygen of the oxide combine together to form water, which, evaporating, leaves chlorine in union with the mercury, as a biperchloride or corrosive sublimate. For medicinal purposes, corrosive sublimate is formed by the complex affinity which operates when chloride of sodium and bipersulphate of mercury are sublimed together. The quantities required for mutual decomposition are two equivalents of chloride of sodium, consisting of two equivalents of chlorine and two equivalents of sodium; and one equivalent of bisulphate of mercury, consisting of one equivalent of mer-

cury, two equivalents of oxygen and two equivalents of sulphuric acid. The two equivalents of chlorine combine with the one equivalent of mercury, to form one equivalent of corrosive sublimate, which is sublimed, and the two equivalents severally, of sodium, oxygen and sulphuric acid, by their union, form two equivalents of dry sulphate of soda as a residue.

Q. What are the properties of corrosive sublimate?

A. It is of a white colour, crystalline, semi-transparent, heavy, of an acrid and corrosive taste, soluble in water, alcohol and ether, it forms a very soluble compound with muriate of ammonia, and it is a virulent poison.

Q. What are antidotes for poisoning from corrosive sublimate?

A. Albumen and gluten, which convert it into calomel. With this view, in case of poisoning, eggs should be largely administered, and, if they be not at hand, wheat flour mixed with water should be substituted.

Q. What are the tests for corrosive sublimate, or salts of mercury?

A. Sulphydric acid, (sulphuretted hydrogen,) lime water, the pure and carbonated alkalies, idohydrate of potash, ammonia, protomuriate of tin and nitrate of silver. Sulphydric acid precipitates the black sulphide of mercury, lime water a yellow peroxide of mercury, and the same is precipitated by the pure fixed alkalies; the carbonated alkalies give a brick red precipitate of the carbonate of the peroxide. Idohydrate of potash precipitates the deutoiodide of mercury, which is of a pale scarlet colour, and is not liable to ambiguity, as there is no other iodide resembling it. Ammonia throws down a white precipitate, which is the precipitatum album of the shops: it consists of muriate of ammonia and peroxide of mercury, each one equivalent. Protomuriate of tin causes at first a white, afterwards a grayish black coloured precipitate of metallic mercury

in a divided state. Nitrate of silver causes a heavy white precipitate of chloride of silver, which blackens on exposure to light; this test can only detect the chlorine of the chloride, but not the mercury. In addition to these there are other tests, such as cyanoferrite of potash, which gives a white precipitate of the cyanoferrite of mercury; and a bright iron plate becomes covered with a grayish film by exposure in a mercurial solution. A polished piece of gold, moistened with a mercurial solution, when touched through the solution with a piece of iron, becomes of a silvery white. The mercurial salts are all volatilized by heat.

Q. Does cyanogen combine with mercury?

A. Yes. There is a bicyanide obtained by boiling the red oxide of mercury with Prussian blue.

COPPER.

Q. How is copper found in nature?

A. In its metallic state and as an oxide, carbonate and sulphide.

Q. How is the metal reduced?

A. By first heating the sulphide, by which the sulphur is volatilized, and the metal oxidized; the resulting oxide is then reduced by means of charcoal. By precipitation from solution, by means of iron, copper may be obtained in its greatest purity.

Q. What are the properties of copper?

A. It is of a red colour, very malleable and ductile, next to iron in tenacity, a good conductor of caloric, and fusible at a white heat. Its specific gravity is 9.

Q. How many oxides of copper are there?

A. Three; a protoxide, a peroxide, and a dioxide. The pro-

toxide is obtained by exposing the metal to a red heat, the peroxide by subjecting the nitrate to intense heat, and the dioxide forms the dull exterior coating of copper as it comes from the manufacturers.

Q. What properties distinguish the oxides of copper?

A. The protoxide is of a red colour, with the exception of muriatic it is insoluble in acids, and is attractive for oxygen. The peroxide is of a black colour, combines with acids to form salts, and with ammonia it forms an intense blue colour.

Q. How many chlorides of copper?

A. Two; a fixed proto-chloride, and a volatile perchloride.

Q. What are the salts of copper?

A. The nitrate, sulphate, muriate and carbonate.

Q. How is the nitrate formed?

A. By the action of dilute nitric acid on copper. A part of the nitric acid is decomposed into oxygen, which peroxidizes the metal, and nitric oxide which escapes, as a nitrous acid red fumes, while the other part of the nitric acid combines with the peroxide, to form the nitrate in question.

Q. How is ammoniacal nitrate of copper made?

A. By adding aqua ammonia to a solution of the nitrate.

Q. How is sulphate of copper formed?

A. Either by boiling sulphuric acid on the metal or on a large scale, by exposing sulphide of copper to air and moisture. It is in composition a bi-persulphide of copper, called in common language blue vitriol.

Q. How is the carbonate obtained?

A. By the double decomposition of an alkaline carbonate with the sulphate of copper.

Q. How is the cuprum ammoniatum of the shops formed?

A. By triturating together sulphate of copper, and carbonate of ammonia.

Q. What are the alloys of copper with tin and zinc?

A. With the former are bronze and bell metal, with the latter it forms brass.

Q. What are the tests for copper?

A. Iron, ammonia, cyanoferrite of potash, and idohydric acid. Iron precipitates, pure copper, ammonia, a blue, and the cyanoferrite of potash, a rich, reddish brown precipitate of cyanoferrite of copper. Idohydric acid produces the insoluble iodide of copper.

LEAD.

Q. In what state is lead found in nature?

A. As an oxide, sulphide and salt. The most abundant ore is the native sulphide, known by the name of Galena.

Q. How is the metal reduced?

A. By heating galena with charcoal.

Q. What are the properties of lead?

A. It is of a blueish colour, tarnishes on exposure to the air, it is soft, flexible, inelastic, ductile in large masses, inferior in tenacity, fusible at 600°, and its specific gravity is 11.352.

Q. How many oxides of lead are there?

A. Four; dioxide, or dross, protoxide, bioxide and red oxide or minium.

Q. How is the protoxide procured?

A. By collecting the pellicle off of melted lead, usually called massicot.

Q. What are the properties of massicot?

A. It is of a yellow colour, insoluble in water, and is the base of all the salts of lead.

Q. What is litharge?

A. It is the vitrified massicot made by partially fusing the

latter, and generally contains a little of the deutoxide. With resin litharge forms adhesive plaister.

Q. What is minium or red lead?

A. It is a mixture of the protoxide and peroxide, generally made by heating litharge in the air. This is called deutoxide of lead by Turner, and is incapable of uniting with acids to form salts.

Q. What results from the action of nitric acid on red lead?

A. It is resolved into protoxide and peroxide of lead, the former unites with the acid, the latter remains as an insoluble powder.

Q. How is the peroxide formed?

A. By treating red lead with nitric acid, which dissolves the protoxide and leaves the peroxide. This oxide is of a pure brown colour, does not unite with acids, and is resolved by heat into protoxide of lead and oxygen gas.

Q. Is there a sulphide of lead?

A. Yes. It is formed either by precipitating a solution containing lead, by means of sulphydric acid gas, or fusing lead and sulphur together.

Q. Is there a chloride and iodide of lead?

A. Yes. The former may be obtained by adding muriatic acid to a solution of sugar of lead, the latter by adding idohydric acid to the same salt.

Q. What are the salts of lead?

A. The nitrate, sulphate, carbonate, and acetate of lead.

Q. How is the nitrate and sulphate formed?

A. By the action of nitric acid on lead we obtain the former, and by boiling sulphuric acid on the metal the latter is obtained.

Q. How is the acetate (sugar of lead) formed?

A. By the action of acetic acid on lead. It may be prepared

either by dissolving litharge in distilled vinegar, or by subjecting plates of lead to this acid, and evaporating the solution.

Q. What is produced by the action of vinegar on lead?

A. The carbonate of lead, which is the white lead of commerce.

Q. What is an antidote for the poisonous effects of lead?

A Any soluble sulphate, which converts the lead into an insoluble salt. On account of its insolubility the sulphate of lead is not poisonous.

Q. What is the best test for lead?

A. Sulphydric acid (sulphuretted hydrogen) which forms the black sulphide of lead.

TIN.

Q. How does tin occur in nature?

A. As an oxide and sulphide. The metal is reduced from the ore, which is the deutoxide, by means of heat and charcoal.

Q. What are the properties of tin?

A. It is of a shining lustre, very malleable and ductile, and produces a peculiar crackling noise when its ingots are bent to and fro. Its specific gravity is 7.9. Pure tin is generally known by the name of block tin.

Q. What are the habitudes of tin with oxygen, chlorine and sulphur?

A. It forms two oxides, two chlorides and two sulphides.

Q. What is formed by the action of nitromuriatic acid on tin?

A. The fuming liquor of libavius, which is a bisulphide.

Q. What is the proper solvent of tin?

A. Muriatic acid, which forms with it a muriate of tin.

Q. Of what utility is the muriate of tin?

A. In consequence of its affinity for oxygen, it destroys the colour of ink and Prussian blue. It is a test for gold and platinum, giving a purple coloured precipitate with the former, and a claret coloured one with the latter.

Q. How has cadmium been found?

A. With the ores of zinc, from which it can be obtained by precipitating a solution of the ore in sulphuric acid, by means of sulphuretted hydrogen.

BISMUTH.

Q. How does bismuth occur in nature?

A. Alloyed with cobalt and arsenic, and as a sulphide.

Q. How is the metal reduced?

A. By the fusion of the native alloy over a heated furnace, with an aperture at the bottom, through which it passes into a vessel.

Q. What properties characterize bismuth?

A. It is white, with a peculiar tint of red, brittle, not malleable nor ductile, an inferior conductor of heat, and crystallizable. Its proper solvent is nitric acid, forming a nitrate of bismuth.

Q. What results from throwing the nitrate into water?

A. A fine white subnitrate, called magistery of bismuth precipitates. If the solution contains muriatic acid, pearl white is formed.

Q. Of what utility are these precipitates?

A. As pigments to improve the complexion.

Q. What are the habitudes of bismuth with oxygen, chlorine and sulphur?

A. There are two oxides, one chloride, and one sulphide of bismuth.

IRON.

Q. How does iron occur in nature?

A. As a sulphide, an oxide, and alloyed with nickel and cobalt. Iron is very abundant, and likely forms the most universal colouring principle.

Q. How is metallic iron obtained?

A. By heating its native oxides with charcoal.

Q. What are the properties of iron?

A. It is of a peculiar gray colour, duetile, malleable, attracts the magnet, very infusible, hard, of a fibrous texture, and the most tenacious of all metals. Iron is capable of being hardened by heat followed by sudden refrigeration, and is susceptible of the welding process. Its specific gravity is estimated at about 7.7, and equivalent, 28.

Q. What are the habitudes of iron, with oxygen, chlorine and sulphur?

A. There are two oxides, with an intermediate one, two chlorides and two sulphides.

Q. How is the protoxide formed?

A. Either by the action of muriatic or diluted sulphuric acid, on the metal, or by passing dry hydrogen gas over the peroxide of iron at a low temperature.

Q. What are the peculiarities of this oxide?

A. It is of a dark blue colour, very combustible, attracts the magnet, its salts absorb oxygen from the air, and it is soluble in water, impregnated with carbonic acid.

Q. How is the peroxide obtained?

A. It may be formed by dissolving iron in nitro-muriatic acid, and adding an alkali, or by heating the sulphate. It oc-

curs native as red hæmatite. This oxide is of a red colour, and incapable of attracting the magnet. It consists of one atom of iron to one and a half of oxygen.

Q. How is the intermediate oxide obtained?

A. By subjecting iron, at a red heat, to steam. The scales of finery cinder is a compound of the two oxides. It is of a black colour.

Q. How is protochloride of iron formed?

A. By evaporating a solution of the proto-muriate to dryness and heating to redness.

Q. How is the perchloride formed?

A. By burning iron wire in an atmosphere of chlorine.

Q. What is prussian blue?

A. It is the cyanoferrite of iron, obtained by mixing cyanoferrite of potassa with a per salt of iron in excess and washing the precipitate; or by the reaction of sulphate of iron in solution and cyanide of potassium. The acid and oxygen take the potassium, while the cyanogen, by combining with the oxide of iron and hydrogen, forms a cyanhydrate of iron; at the same time, a cyanide of iron is formed, which uniting with the cyanhydrate forms cyanoferrite of iron.

Q. How is cyanoferrite of potash obtained?

A. By digesting cyanhydrate of potash, (formed by mixing prussic acid and liquid hydrate of potash together) with the protoxide of iron; or by digesting prussian blue with potash until the latter is neutralized.

Q. What are the magnetic iron pyrites?

A. The proto-sulphide. It may be made by the combustion of iron with sulphur. The bi-sulphide is the common iron pyrites.

Q. What does iron form with carbon?

A. Steel, cast iron and plumbago, (black lead.) Black lead

is carbon in unison with about 5 per cent. of iron. Steel is made by heating pure iron with charcoal in ovens without access of air. By fusion, steel forms cast iron.

Q. What are some of the most important salts of iron?

A. The sulphate, carbonate, phosphate and muriate.

Q. What properties distinguish the salts formed with the protoxide from those formed with the peroxide of iron?

A. The prosalts are of a green colour, crystallizable, and insoluble in alcohol; the persalts are of a brown colour, uncrystallizable, and soluble in alcohol.

Q. How is the protosulphate of iron formed?

A. By the action of diluted sulphuric acid on metallic iron, or by exposing the protosulphide to air and moisture.

Q. Does carbonic, like sulphuric acid, unite with peroxide of iron?

A. No. Carbonate of the protoxide is formed by the double decomposition which ensues between carbonate of soda, and protosulphate of iron, sulphate of soda and carbonate of iron results, the former remaining in solution, the latter precipitated.

Q. How is phosphate of iron formed?

A. By the double decomposition between phosphate of soda and sulphate of iron, which results in the formation of sulphate of soda and phosphate of iron.

Q. How is the muriate of iron obtained?

A. By the action of dilute muriatic acid on iron.

Q. What precipitates the oxides of iron from their salts in solution?

A. The pure and carbonated alkalies throw down the hydrate of the peroxide of iron from solutions of the persalts, and the pure alkalies, the hydrate of the protoxide, from solutions of the salts of the protoxide of iron.

Q. What are the tests for iron?

A. Cyanoferrite of potash, galls and other vegetable astrin-

gents containing tannin, succinic and meconic acids. The precipitate produced by the cyanoferrite, is of a blue colour, and is the cyanoferrite of iron, (Prussian blue;) that from galls, is an ink coloured tannogallate of iron; succinic acid produces a brown coloured succinate, and meconic acid gives a red meconate of iron.

ZINC.

Q. In what states is zinc found in nature?

A. As an oxide, sulphate, silicate, carbonate and sulphide. The silicate and carbonate are known in mineralogy under the name of calamine, and the sulphide as blende.

Q. How is the metal reduced?

A. By heating its oxide with charcoal.

Q. What are the properties of zinc?

A. It is brilliant, of a white colour, with a slight leaden hue, of a crystalline structure and lamellated texture, fusible and soluble in nitric and muriatic acids. The specific gravity of zinc is 7.

Q. What is butter of zinc?

A. It is the chloride, formed by subjecting the metal to chlorine gas.

Q. What are flowers of zinc?

A. It is the only oxide, which is a protoxide of zinc.

Q. What is an important salt of zinc?

A. The sulphate or white vitriol. It is obtained either by roasting blende, or by the action of sulphuric acid on metallic zinc.

Q. What is produced by having a piece of zinc suspended in a solution of acetate of lead?

A. A precipitate of lead called arbor saturni.

ARSENIC.

Q. In what state does arsenic occur in nature?

A. As an oxide, sulphide and alloy. It is sold in commerce under the name of cobalt, which is considered an oxide of arsenic.

Q. How is the metal reduced?

A. By heating intensely with charcoal either the white oxide of arsenic or native cobalt.

Q. What are the properties of metallic arsenic?

A. It is a bright crystalline solid, brittle, and when heated before the blow pipe it burns before it fuses, emitting copious white fumes which have the odour of garlic.

Q. What is the white arsenic of the shops?

A. It is the white oxide, obtained by subliming the native cobalt or metallic arsenic, and is called arsenious acid.

Q. What are the properties of arsenious acid?

A. It is a white powder, soluble in water, reddens vegetable blues, and combines with salifiable bases, forming salts which are termed arsenites. It is composed of arsenic, one equivalent, to oxygen one and a half. It is very poisonous.

Q. What is arsenic acid?

A. It is the peroxide of arsenic, obtained by the action of nitro-muriatic acid on the metal, or by deflagrating the latter with nitre.

Q. What properties distinguish this oxide?

A. It is white, much more soluble than arsenious acid, of a sour taste, and forms with salifiable bases, arseniates.

Q. What preparation of arsenic is used in medicine?

A. Fowler's solution, which is obtained by boiling pearl

ash on the white oxide of arsenic. According to the United States Pharmacopœia, it is made by boiling arsenious acid and carbonate of potash, each sixty-four grains, with a pint of distilled water until the acid is entirely dissolved. To the solution, when cold, add four fluid drachms of the compound spirit of lavender, and afterwards sufficient distilled water to make up the measure of a pint. It is an arsenite of potash in solution, the carbonic acid being expelled.

Q. What results from the deflagration of arsenious acid with nitre?

A. An arseniate of potash, a salt formed by the union of arsenic acid and potash.

Q. What properties characterize the arsenites and arseniates?

A. Excepting those of potash, soda and ammonia, the arsenites and arseniates are very sparingly or quite insoluble in water, but soluble in nitric acid, and most other acids with which their bases do not form insoluble compounds. They are decomposed by copper and silver, and destroy the colour of the iodide of starch.

Q. What is formed by exposing arsenic to chlorine gas?

A. A liquid chloride, analogous to the bi-chloride of tin.

Q. How many native sulphides are there?

A. Two; one called realgar, which is crystalline, of a ruby red colour, and is a proto-sulphide, the other, called orpiment, which is of a yellow colour, and is considered as a persulphide of arsenic. According to Turner, there are three sulphides, and orpiment is regarded by him as the sesqui or intermediate one. Orpiment is the colouring principle of a paint called king's yellow.

Q. Can this sulphide be produced by artificial means?

A. Yes; it is made by passing sulphuretted hydrogen gas through a solution containing arsenious acid.

Q. Is there a compound of arsenic with hydrogen?

A. Yes; it is a solid, its vapour burns with a pale blueish white flame.

Q. What are the tests for arsenious acid?

A. Lime water, ammoniacal nitrate of copper, ammoniacal nitrate of silver, sulphydric acid, (sulphuretted hydrogen,) and the reduction of the metal itself. Lime water precipitates the white arsenite of lime, which is soluble in all acids that are capable of dissolving lime. The ammoniacal nitrate of copper gives an apple green precipitate, which is an arsenite of copper, called Scheele's green, and the ammoniacal nitrate of silver gives a bright yellow arsenite of silver. Sulphuretted hydrogen produces a yellow precipitate, which is a pure orpiment or sesqui-sulphide of arsenic.

Q. What is the best precipitant for arsenic acid?

A. The ammoniacal nitrate of silver, which results in a brick red arseniate of silver.

Q. What is the best mode of detecting arsenic in a stomach which is suspected to contain it?

A. By subjecting the mass or contents of the stomach to heat, with powdered charcoal, in a glass tube, metallic arsenic will be evolved, which sublimes in crystals. When it is much intermingled with other matter, it is preferable to evaporate a solution of the mass to dryness, and then digest in nitric acid, until this acid is expelled or decomposed, by which all the organic matter will be destroyed, and the arsenious converted into arsenic acid. It may then be subjected to the common tests, or reduced by means of heat and charcoal.

Q. Why is lime water objectionable as a test for arsenic?

A. Because it yields white precipitates, with carbonic, phosphoric, oxalic and tartaric acid, and the arsenite is so light a powder as to escape detection in milk or gelatinous solutions.

Q. What renders the ammoniacal nitrate of silver or copper fallible tests for arsenious acid?

A. Phosphoret of silver is yellow, like the arsenite, and many substances containing no arsenic, give to the copper a green colour.

Q. Is the colour of the precipitate produced by sulphuretted hydrogen, peculiar to arsenic alone?

A. No; with antimony, tin, cadmium and selenium, this gas gives yellow coloured precipitates.

ANTIMONY.

Q. In what state is antimony found in nature?

A. As a metal and a sulphide. The antimony of the shops is a sulphide. Pure antimony is usually designated by the name of regulus of antimony.

Q. How is metallic antimony reduced?

A. Either by heating the sulphide with iron filings, which detains the sulphur, or by mingling the sulphide with two-thirds of its weight of bitartrate of potash, and one third of its weight of nitre, and deflagrating the mixture in a red hot crucible. The metal being oxidized, and the sulphur acidified by the oxygen of the nitre, the resulting oxide of antimony is reduced by the carbon of the tartaric acid. The principal mines from which antimony is obtained are in France and Germany.

Q. What properties characterize metallic antimony?

A. It is brilliant, of a bluish white colour, brittle, of a crystalline structure, odorous when rubbed, fuses below a red heat, and when fused and thrown upon a board it scintillates. The specific gravity of antimony is 6.7, and its equivalent weight is represented by 44.

Q. What are the habitudes of antimony with oxygen, sulphur and chlorine?

A. There are three oxides, three sulphides, and three chlorides of this metal.

Q. Which is the most important oxide of antimony?

A. The protoxide; it is this oxide only which forms salts with acids, and is medicinal. The deutoxide and peroxide are acids; the former is called antimonious, and the latter antimonic acid.

Q. How is the protoxide obtained?

A. There are several modes of forming this oxide. The process now generally adopted is to wash the precipitate, formerly called powder of Algaroth, which is made by pouring the protochloride or muriate of antimony into water. When the chloride or butter of antimony is poured into water, it becomes a muriate, which is decomposed by the water into muriatic acid, and protoxide of antimony, the latter falling down as a submuriate, because it contains a little muriatic acid. To obtain the protoxide in its greatest purity, it is best to digest this precipitate with a dilute alkaline solution, until it is free from acid. This oxide is called by the Dublin and United States pharmacopœias nitro-muriatic oxide of antimony, in consequence of their making the chloride by dissolving the sulphide of antimony in muriatic with a small quantity of nitric acid. The protoxide may also be obtained by precipitation from tartar emetic in solution, by means of carbonate of potash or soda.

Q. What are the properties and uses of this oxide?

A. It is a white powder, with somewhat of a dirty appearance, fusible, at a red heat yielding a yellow fluid, and it is used for making tartar emetic.

Q. How is antimonious acid procured?

A. By digesting metallic antimony, or its oxide, in nitric acid, and exposing the resulting hydrate of the peroxide to a

strong heat. This oxide is also obtained by exposing metallic antimony, or the protoxide, to intense heat.

Q. What properties distinguish this oxide?

A. It is white, and very infusible, being less fusible and more volatile than the protoxide. It sublimes by heat, and condenses into crystals of a silvery whiteness, called argentine flowers of antimony. It is insoluble in water, and likewise in acids after being heated to redness, and unites with alkalies to form antimonites.

Q. How is antimonic acid procured?

A. By digesting the metal in strong nitric acid, or dissolving it in nitromuriatic acid, and pouring the solution into water, there is precipitated the hydrate of the peroxide, which is of a white colour, and soluble. By subjecting this to the temperature of 500° or 600°, it is converted into a pure peroxide.

Q. What is the character of this oxide?

A. It is of a yellow colour, insoluble in water and muriatic acid.

Q. What is the alleged composition of antimonious and antimonic acid?

A. The former frequently designated as the deutoxide of antimony, consists of one equivalent of antimony to one and a half of oxygen; the latter, or peroxide, consists of one equivalent of metal to two of oxygen. Hence the oxides of antimony ought to be designated by the more correct terms of protoxide, sesquioxide and deutoxide.

Q. What are the chlorides of antimony?

A. A protochloride, a deuto or bichloride and a dichloride.

Q. How is the protochloride made?

A. Either by burning antimony in chlorine gas, by distilling the sulphide with corrosive sublimate, or dissolving the sulphide in dilute muriatic acid. The United States Dispensatory directs the following:—Take of the sulphide 2 ounces, muri-

atic acid $12\frac{1}{2}$ fluid ounces, nitric acid a drachm, water a gallon. Having mixed the acids, add by degrees the sulphide until effervescence ceases; then boil one hour. The oxygen of the water in this process converts the metal into protoxide, which, uniting with the acid, forms muriate of antimony in solution, while the hydrogen, uniting with the sulphur, forms sulphydric acid, the extrication of which causes the effervescence. Hence we have a solution of protochloride of antimony.

Q. What are the properties of the protochloride of antimony?

A. It is a soft solid, of a yellow white colour, and semi-transparent, crystallizes on cooling, deliquesces on exposure to the air, and when mixed with water it is converted into muriatic acid and protoxide of antimony. From its peculiar consistence it is called butter of antimony.

Q. What is formed by passing dry chlorine over heated antimony?

A. The bichloride. It is a transparent volatile liquid, which emits fumes on exposure to the air.

Q. What is the dichloride?

A. It is two equivalents of metal to one equivalent of chlorine.

Q. How is the simple sulphide of antimony formed?

A. By fusing antimony with sulphur.

Q. What is formed when protosulphide of antimony is boiled with an aqueous solution of potash?

A. A liquid is formed, which, on cooling, yields a reddish brown precipitate, known under the name of kermes mineral. According to Thompson, kermes mineral is a sulphohydrate of antimony, or hydrosulphuretted oxide of antimony. Gay-Lussac regards it as an oxysulphide; that is, a combination of the sulphide with the protoxide of antimony. Assuming the latter composition, its formation is thus explained:—By the mutual reaction of water, and a part of the sulphide of anti-

mony, sulphydric acid (sulphuretted hydrogen) and protoxide of antimony are formed; the former of which unites to the potassa as a hydrosulphate of potassa in solution, and the latter to the remainder of the sulphide to form the kermes. This being very soluble at the boiling temperature in the sulphohydrate of potash, but at common temperatures being much less so, it is in part precipitated on the cooling of the solution.

Q. What properties characterize kermes mineral?

A. It is a dark brown powder, which becomes lighter on exposure to the air, and is decomposed by muriatic acid and heat, with the extrication of sulphuretted hydrogen. According to Thompson the kermes consists of antimony, sulphur, oxygen and hydrogen each one equivalent.

Q. What results from the addition of an acid to the alkaline solution.

A. A further precipitation ensues. This precipitate mixed with the kermes is known in pharmacy as the golden sulphur of antimony. In consequence of the complicated changes going on in the solution from which kermes is precipitated, by the addition of an acid, sulphur is set free with extrication of sulphuretted hydrogen. Thompson regards the composition of the golden sulphur as kermes mineral, with one equivalent of sulphur.

Q. How is the rationale of this second precipitation explained?

A. By supposing the solution which remains after the kermes is thrown down, to absorb oxygen; by which part of the sulphuretted hydrogen is decomposed, its hydrogen combining with the oxygen absorbed, and its sulphur by uniting with the remaining, undecomposed sulphydric acid, (sulphuretted hydrogen) results in the formation of sulphuretted hydrosulphate of potash. Assuming these changes to have taken place, it may be explained thus: on addition of the acid which

causes neutralization of the solvent of the kermes, more of the latter will fall down; and from the consequent decomposition of the sulphuretted hydro-sulphide, sulphuretted hydrogen and sulphur is set free, the former being evolved, the latter precipitated.

Q. What are the striking properties of the golden sulphur?

A. It is an orange coloured powder, insoluble, inodorous, burns with a greenish blue flame, giving off sulphurous acid. It is soluble in solutions of the caustic fixed alkalies.

Q. How is the bi-sulphide of antimony obtained?

A. By the action of sulphuric acid on peroxide of antimony.

Q. What is the common red antimony?

A. It is a native compound of one atom of protoxide of antimony with two atoms of the sulphide.

Q. What is the glass of antimony.

A. A combination of eight parts of protoxide of antimony to one of sulphide. It is prepared by the partial roasting of the sulphide and subsequent fusion.

Q. What are the properties and uses of this preparation?

A. It is of a vitreous appearance, of a steel gray colour, insoluble in water, and used by the London college for making tartar emetic.

Q. What is the crocus of antimony?

A. It is a liver brown, opaque mass, formed by deflagrating sulphide of antimony with nitre. Its composition, according to Proust, is three parts of protoxide of antimony to one of sulphide. This is used by the Edinburgh formula for making tartar emetic.

Q. What is pulvis antimonialis?

A. It is a combination of oxide of antimony with phosphate of lime. It is the imitation powder of the celebrated Dr. James.

Q. What is tartar emetic?

A. It is the tartrate of antimony and potash.

Q. How is it obtained?

A. By boiling bi-tartrate of potash, (cream of tartar,) with either the sulphate, the glass, the crocus, or protoxide of antimony. The oxide is the best. By the Dublin and United States formula, it is made by taking the nitro-muriatic oxide of antimony, (protoxide,) two ounces, bi-tartrate of potash, in very fine powder, two ounces and a half, distilled water, eighteen fluid ounces. Boil the water in a glass vessel; then add the powders previously mixed together, and boil for half an hour; lastly, filter the liquor through paper, and set it aside to crystallize. The principle of the formation of tartar emetic is merely the saturation of the excess of tartaric acid in the bi-tartrate of potassa, with protoxide of antimony.

Q. What are the properties of tartar emetic?

A. It is a white salt, inodorous, of a nauseous taste, crystalline, and its crystals effervesce on exposure to the air, soluble in water, insoluble in alcohol, and decomposed by the alkalies and their carbonates, and various astringent vegetable infusions.

Q What are tests of the goodness of tartar emetic?

A. By its yielding no precipitates with baryta, oxalic acid, nitrate of silver, or acidulous sugar of lead, and its entire solubility in a small quantity of water. The crystalline character of this salt is considered among the best tests of its purity.

Q. What is the composition of this salt?

A. It consists of one equivalent of potassa, three equivalents of the protoxide of antimony, two equivalents of tartaric acid and two equivalents of water. Hence, it may be considered to consist of one equivalent of cream of tartar and three equivalents of the protoxide.

Q. What are antidotes for an over dose of tartar emetic?

A. If vomiting is not immediately induced, give a large quantity of cinchona in decoction or infusion ; and if this be not at hand, decoctions of common tea should be administered.

Q. Does sulphuric acid act on antimony ?

A. No ; with heat sulphuric acid oxidizes the metal by the decomposition of a portion of the acid, while the other portion combines with the oxide thus formed, as the sulphate of antimony.

Q. How are the antimonial salts tested ?

A. By the carbonate of potash or soda, which precipitates the protoxide of antimony ; or by sulphuretted hydrogen, which throws down the yellow coloured sulphide or kermes mineral.

METALS PROPER OF MINOR IMPORTANCE.

Q. Enumerate a few of the unimportant metals.

A. Palladium, osmium, iridium, rhodium, &c.

Q. Where are these found ?

A. In union with, accompanying the native grains of platinum as imported from South America.

NICKEL.

Q. In what state does nickel exist ?

A. As an arsenuret, and in union with sulphur.

Q. How is it separated from its alloys?

A. By the solubility of its protoxide in caustic ammonia.

Q. What are the properties of nickel?

A. It is white, and magnetic, and in habitude similar to copper.

Q. Where is cadmium found?

A. With the ores of zinc, from which it can be obtained by precipitating a solution of the ore in sulphuric acid by means of sulphydric acid.

CHROMIUM.

Q. How does chromium occur in nature?

A. As chromate of lead and chromate of iron. The former is a splendid orange colour, and used as pigment.

Q. What is chromic acid?

A. It is a peroxide of chromium.

Q. What is the peculiarity of chromic acid?

A. Its producing beautiful precipitates with various metals.

COBALT.

Q. How is cobalt generally found?

A. In union with arsenic, which may be obtained by heating the native oxides with charcoal.

Q. What is formed by heating cobalt in the air?

A. Arsenic is expelled, leaving behind an impure oxide called zaffre.

Q. What properties distinguish cobalt?

A. It is brittle, of a reddish gray colour, and a magnetic metal.

Q. What can be said of columbium?

A. It is brittle and very infusible metal, possessing but little importance.

MANGANESE.

Q. How is manganese found in nature?

A. Principally as a black peroxide.

Q. Of what utility is this oxide?

A. As a source for obtaining oxygen gas, an ingredient in glass, and is one of the agents in evolving chlorine.

Q. What is a remarkable property of manganese?

A. The number of compounds it forms with oxygen.

Q. What is chameleons mineral?

A. It is a compound resulting from the fusion of the black oxide with potash. The aqueous solution of this compound becomes successively blue, red, violet, and at last, colourless.

Q. Enumerate some unimportant metals?

A. Molybdenum, titanium, tungsten, cerium, uranium and vanadium.

SALTS.

Q. What is a salt defined to be?

A. A soluble compound, (containing one or more acids or corrosive ingredients,) the qualities of the ingredients being either neutralized or modified.—*Hare.*

Q. What is the nomenclature of salts?

A. Acids, of which the name terminate in *ous*, have their salts distinguished by a termination in *ite*. Acids, of which the names end in *ic*, have their salts distinguished by a termination in *ate*. Thus we have *nitrites* and *nitrates—sulphites* and *sulphates*.

Q. What is a *super* salt?

A. A salt in which the acid is in excess. Thus we have *super* tartrate of potash, (cream of tartar.) Those salts which have a double proportion of acid, have the letters *bi* prefixed; thus we have bi-carbonate.

Q. What is a sub-salt?

A. It is one in which the base is in excess. Thus we have sub-carbonate of ammonia.

Q. What are the different salts?

A. The chlorates, nitrates, sulphates, phosphates, carbonates, chromates, iodates and idohydrates, arseniates and sulpho-hydrates.

CHLORATES.

Q. How are the alkaline chlorates obtained?

A. By passing chlorine gas into an alkaline solution. The decomposition of water furnishes hydrogen to one portion of chlorine forming muriatic acid, and oxygen to another portion forming chloric acid; which, by the union of the two acids with the alkaline base, form a muriate which remains in solution, and a chlorate which precipitates. None of the chlorates are found in nature.

Q. Are the chlorates soluble in water?

A. Yes; excepting that of mercury, which is sparingly so.

Q. Are they decomposed by heat?

A. Yes; they give up their oxygen simply by heat, and explode from slight causes.

Q. What properties distinguish the chlorates?

A. They deflagrate violently with combustibles, and are converted into chlorides; by the action of muriatic acid, chlorine, with protoxide of chlorine is disengaged, and by that of sulphuric acid, peroxide of chlorine is liberated. They are mostly soluble in water. The proto-chlorate of mercury is sparingly so.

NITRATES.

Q. How are nitrates prepared?

A. By the action of nitric acid on metals, on metallic oxides, or on carbonates. The nitrates of potash, soda, lime and magnesia occur in nature.

Q. Are the nitrates decomposed by heat?

A. Without exception; hence their efficacy as oxidizing agents.

Q. What properties distinguish the nitrates?

A. The three following, namely:—1st. By deflagrating with charcoal and other combustibles. 2d. By their power of dissolving gold leaf on the addition of muriatic acid. 3d. By emitting, when subjected to concentrated sulphuric acid, the dense white fumes of nitric acid. The neutral nitrates are all soluble.

Q What is the residuum left when a nitrate is deflagrated with an acidifiable combustible?

A. The combustible united with the metallic oxide: thus,

when charcoal is used, we have a carbonate; in case of sulphur, a sulphate as a residue.

SULPHATES.

Q. How are sulphates formed?

A. By the action of sulphuric acid on the metals themselves, on the metallic oxides or their carbonates, or by double decomposition. Some of them, as those of lime and baryta, exist in nature.

Q. Are all the sulphates soluble in water?

A. There are six insoluble sulphates; namely, those of baryta, tin, antimony, bismuth, lead and mercury. Those sparingly soluble are the sulphates of strontia, lime, zirconia, yttria, cerium and silver. The remainder are soluble.

Q. Are all the sulphates decomposed by heat?

A. They are, excepting those of the alkalies and alkaline earths.

Q. What properties distinguish the sulphates?

A. Their solutions are precipitated by solutions of barytes. Heated in contact with charcoal or hydrogen gas, they are converted into sulphides, which, if moistened, smell like rotten eggs, in consequence of sulphuretted hydrogen gas being formed. They are almost all insoluble in alcohol.

Q. How can the conversion of a sulphate into a sulphide, by means of charcoal and hydrogen gas, be accounted for?

A. When heated with charcoal, the acid and the oxide are both deprived of oxygen, and carbonic acid is disengaged, while a metallic sulphide remains. A similar change is produced by the hydrogen gas with the formation of water, and sometimes sulphuretted hydrogen.

Q. What is the best test for sulphates in solution ?

A. Muriate of baryta in solution, which precipitates insoluble sulphate of baryta.

PHOSPHATES.

Q. Are the phosphates of artificial or native origin ?

A. Both. Those of lime, manganese, iron, uranium, copper, and lead, are found in nature, while others require artificial means for their production.

Q. What are the distinguishing properties of the phosphates?

A. They give precipitates with solutions of baryta, lime, lead, and silver. They are fusible, undecomposable by heat alone, and excepting those of the alkalies, insoluble in water.

Q. What precipitate does the phosphoret of silver resemble ?

A. Arsenite of silver, though not quite so deep a yellow.

CARBONATES.

Q. Are carbonates of native or artificial origin ?

A. Both. Those of the alkalies and alkaline earths, with many others, occur in nature. By double decomposition most of them are obtained artificially.

Q. What property distinguishes carbonates ?

A. Their decomposition with effervescence, owing to the escape of carbonic acid ; when subjected to the action of nearly all the acids.

Q. Are they decomposed by heat ?

A. Excepting the proper alkaline carbonates, heat alone expels the carbonic acid.

Q. Are carbonates soluble ?

A. The alkaline carbonates are very soluble, the others are sparingly so.

CHROMATES.

Q. What property distinguishes the chromates ?

A. Their yellow or red colour. Chromate of lead is found in nature.

Q. What properties distinguish the borates ?

A. Those of the alkalies are soluble in water, all the others are sparingly soluble; they are not decomposed by heat, very fusible, and detected when digested in a slight excess of sulphuric acid, evaporated to dryness, and the residue is boiled in alcohol, by the solution thus formed, burning with a green flame.

IODATES AND IDOHYDRATES.

Q. How may an iodate and idohydrate be obtained ?

A. By adding iodine to a hot alkaline solution. By the decomposition of water, oxygen will convert part of the iodine into iodic acid, and hydrogen will form with the remaining iodine, idohydric acid, which, by their union with the alkaline base, form an iodate and idohydrate. The iodate is insoluble in water, while the idohydrate being soluble remains in solution.

Q. What properties characterize the iodates ?

A. They form deflagrating mixtures with combustible bodies, by which they are converted into iodides, are decomposable by heat, and are all insoluble in water, excepting those of

the alkalies, which are sparingly so. The strong acids set iodine at liberty by depriving iodic acid of its oxygen.

ARSENIATES.

Q. Are arseniates of natural or artificial origin?

A. Both. The arseniates of lime, nickel, cobalt, iron, copper, and lead, are natural productions.

Q. Are arseniates soluble.

A. Excepting those of potash, soda, and ammonia, they are sparingly soluble in water, but are dissolved in dilute nitric acid, and are thrown down again unchanged by ammonia.

Q. Are they decomposed by heat?

A. They generally bear a red heat without decomposition, but are decomposed by being heated to redness with charcoal

Q. How are these salts detected?

A. The soluble arseniates are easily distinguished by the usual tests for arsenious acid; and the insoluble arseniates when boiled in a strong solution of the fixed alkaline carbonates, are deprived of their acid, and may then be detected in the usual manner.

SULPHOHYDRATES.

Q. What are sulphohydrates?

A. Compounds of sulphuretted hydrogen with oxides.

Q What properties distinguish them?

A. The weak affinity between the acid and base, and consequent decomposition by most other acids, with disengagement of sulphuretted hydrogen. They are decomposed also by chlo-

rine and iodine with separation of sulphur, and formation of a muriate, or idohydrate.

Q. What change do they undergo when their solutions are exposed to the air ?

A. From being colourless or nearly so, they absorb oxygen, a portion of its acid is deprived of hydrogen, and a yellow coloured sulphuretted sulphohydrate is generated. By continued exposure, the whole of the sulphuretted hydrogen is decomposed, water and hypo-sulphurous acid being produced.

Q. What are cyanhydrates?

A. Compounds of cyanhydric acid with bases, formed by the decomposition of water, by means of a cyanide in solution.

Q. What is an important salt of this class ?

A. Cyanhydrate of potash.

Q. Are there any important cyanoferrites ?

A. Yes ; cyanoferrite of potash, and cyanoferrite of iron.

Q. What is fulminating mercury ?

A. It is the cyanate of mercury.

Q. How obtain it ?

A. By dissolving mercury in nitric acid, with heat, and when cold, add alcohol, then heat until effervescence takes place, and when red fumes appear check the action with water. The precipitate well washed with water, and afterwards dried at a gentle heat, will be the cyanate of mercury.

Q. Is chlorine capable of uniting with metallic oxide ?

A. Yes; by the action of chlorine on lime, chloride of lime is formed.

ORGANIC SUBSTANCES.

Q. Why is a knowledge of organic chemistry of less difficult acquirement than that of the chemistry of inorganic substances?

A. Because the ultimate elements are less in number and well known.

Q. What are characteristics of organic substances?

A. They are composed of the same elements, very prone to spontaneous decomposition, that it is impossible to form them by artificial means, and they are all decomposed by red heat.

Q. How is organic chemistry divided?

A. Into vegetable and animal chemistry.

VEGETABLE SUBSTANCES.

Q. What are the ultimate elements of vegetable substances?

A. Hydrogen, oxygen, and carbon. Some of the alkalies and alkaline earths, with minute portions of iron also exist in vegetables. The vegetable alkalies contain nitrogen.

Q. What results when vegetable substances are exposed to heat simply?

A. The water and carbonic acid existing in them is expelled.

Q. What results when subjected to distillation in close vessels?

A. First, the water and essential oils existing in them;

then carbonic oxide and carbonic acid ; by the union of hydrogen and carbon in different proportions we have essential oils ; and by further ignition the oils and bituminous matter are converted into carburetted hydrogen.

Q. Do any of the acids act on vegetable substances?

A. Muriatic and sulphuric acids act upon them in consequence of their affinity for water. Nitric acid by imparting oxygen gives rise to the same products as combustion.

Q. What are the compounds called which exist in vegetables?

A. Proximate principles of vegetables.

Q. What influences the properties or activity of vegetable principles?

A. The proportions of the ultimate principles in composition.

Q. Give an illustration of the influence of the proportion of ultimate elements over the qualities of substances.

A. Vegetable substances, in which the oxygen and hydrogen exist in the proper proportion to form water, are mild, being neither acid, alkaline, oily, nor resinous. Those in which the oxygen exist in a less proportion to the hydrogen, are generally oily, resinous, alcoholic, or æthcrial. Those in which the oxygen is in excess to form water with the hydrogen are acid, and the alkaline vegetables contain nitrogen.

Q. Can you enumerate some of the vegetable products that are neither acid, alkaline, oily nor resinous?

A. Gum, sugar, starch, gluten, caoutchouc, lignin and tannin.

Q. What are the characteristic properties of gum?

A. It is neither sweet nor sour, soluble in water, and insoluble in alcohol and æther, precipitated from aqueous solution by acetate of lead, peroxide of iron and mercury.

Q. What are the characteristic properties of sugar?

A. It is white, crystalline, solid, brittle, soluble in its own weight of water, and in alcohol. It unites with alkalies and alkaline earths, and with the oxide of lead, forming compounds. It decomposes some salts, reviving the metal.

Q. What effect has sulphuric and nitric acid on sugar?

A. By the former, it is decomposed with depositions of carbon; by the latter, it is converted into oxalic acid.

Q. What is sugar an antidote for?

A. Acetate of copper, in which it acts by removing a portion of oxygen.

Q. What happens when its aqueous solution is mixed with yeast?

A. It undergoes the process of the vinous fermentation, by which it is converted into alcohol.

Q. What is considered the atomic constitution of sugar?

A. One equivalent of water to one equivalent of carbon; or oxygen, hydrogen and carbon, each one atom.

Q. What are the characteristic properties of starch or fecula?

A. It is white, insipid, inodorous, insoluble in alcohol, æther and cold water, soluble in large quantities of boiling water from which it is precipitated by acetate of lead, and its best test is iodine. Starch forms soluble salts with alkalies, from which it is thrown down by acids.

Q. What effect have diluted acids on starch?

A. They convert it first into gum and then sugar. When heated with nitric acid, it is converted into malic and oxalic acids.

Q. What substance is left after washing away starch from flour?

A. A gray viscid substance, called gluten.

Q. What properties distinguish gluten?

A. It is insoluble in water and æther, but readily soluble in boiling alcohol, and contains nitrogen. It is to the presence of gluten in wheat flour that its nutritive power is attributed.

Q. Give the characteristic properties of caoutchouc?

A. It is an elastic gum, insoluble in water, alcohol, and cold acids, but slowly soluble in æther and the volatile oils. The

oil of cajeput is the best solvent. Dr. Mitchell has discovered that oil of sassafras, after the operation of æther, is a good solvent. It consists of oxygen, hydrogen, carbon, and nitrogen.

Q. What are the properties of lignin?

A. It is insoluble, inodorous, tasteless, and yields, by boiling sulphuric acid upon it, sugar and gum; and by nitric acid, malic, oxalic and acetic acids.

Q. What are the properties of tannin?

A. When pure, it is colourless and inodorous, of an astringent taste, soluble in water, æther, and by the aid of heat, in alcohol. It is precipitated by alkalies, lime water and muriate of tin. The most peculiar property, is its action on a salt of iron and gelatin; with the former it produces a black compound; and the latter, a yellowish flocculent precipitate.

Vegetable substances in which the oxygen is in less proportion than would form water with the hydrogen.

OILS.

Q. What properties characterize oils?

A. They have a peculiar unctuous feel, are inflammable and insoluble in water.

Q. How are oils divided?

A. Into fixed and volatile.

Q. Give the properties of fixed oils?

A. They have but little taste or smell, lighter than water, decomposed by distillation into a volatile oil and carburetted hydrogen, soluble in æther, sparingly soluble in alcohol, and when heated in the air take fire, producing water and carbonic acid.

Q. What are the proximate constituents of fixed oils?

A. Stearin and elain, the latter being most soluble.

Q. What is wax?

A. A concrete fixed oil, very sparingly soluble in boiling alcohol and boiling æther, and not affected by acids.

Q. What properties distinguish volatile oils?

A. They have a penetrating smell and acrid taste, soluble in alcohol, inflame with concentrated nitric acid, and may be evaporated from a surface without leaving a stain.

Q. What is camphor?

A. A concrete volatile oil. It forms an acid by the action of heated nitric acid, and is soluble in the acids. Nitric acid, at common temperature, dissolves camphor, forming what is called oil of camphor.

Q. What is artificial camphor?

A. It is a white, crystalline substance, in odour and volatility resembling camphor, obtained by saturating oil of turpentine with muriatic acid gas.

Q. What are resins?

A. They are concrete, inspissated juices, which exude from certain plants in union with essential oils.

Q. What are the characteristic properties of resins?

A. They are brittle, inflammable, insoluble in water, but are soluble in alchol, æther, volatile oils, alkalies and acids.

ALCOHOL.

Q. In what does alcohol exist?

A. It is the intoxicating ingredient in vinous liquors, and results from vinous fermentation.

Q. How is alcohol obtained?

A. It is separated from the fermented liquors by distillation,

in consequence of its boiling at a lower temperature than water. To produce the purest alcohol, pearl ash or lime is used to attract moisture.

Q. What conditions are required for the process of the vinous fermentation?

A. The presence of sugar, water and yeast, at a temperature between 50 and 120 degrees of F.

Q. How do you explain the conversion of sugar into alcohol?

A. Sugar, consists of oxygen, hydrogen and carbon, in equal proportions. In consequence of the evolution of one equivalent of carbon with two equivalents of oxygen, as carbonic acid, during the process of fermentation, there remain three equivalents of hydrogen, two equivalents of carbon, and one equivalent of oxygen, from the decomposition of three equivalents of sugar, which are required to be present; and these are the equivalent proportions which constitute alcohol.

Q. What are the properties of alcohol?

A. It is a colourless fluid, of a penetrating odour and burning taste, volatile, inflammable, has a less capacity for heat than water, of specific gravity near 800, boils at 176 degrees, and has never been frozen.

Q. With what does alcohol unite?

A. Water with which it produces a rise of temperature and a diminution of bulk.

Q. What does alcohol yield by combustion?

A. Water and carbonic acid.

Q. What are the proximate elements of alcohol?

A. Equal volumes of water and olefiant gas.

Q. What is the effect of sulphuric acid on alcohol?

A. According as the proportions vary, it is decomposed into olefiant gas or sulphuric æther.

ÆTHER.

Q. How is æther obtained?

A. By the action of acids on alcohol.

Q. Do the different acids all operate on the same principle?

A. No; sulphuric acid abstracts water from alcohol. Muriatic acid substitutes a volume of acid vapour for the water, while nitric and acetic acids combine with alcohol.

Q. How is sulphuric æther obtained?

A. By distilling equal weights of alcohol and sulphuric acid, until the appearance of white fumes.

Q. Suppose the heat be continued after the appearance of the white fumes?

A. Sulphurous acid would be disengaged, and an oil called ætherial oil, or oil of wine, pass into the receiver.

Q. Give the properties of æther?

A. It is a colourless fluid of a fragrant odour, pungent taste, very volatile, soluble in alcohol, partly soluble in water, boils at 98 degrees of Fahrenheit, is the proper solvent of volatile oils and resins; and its specific gravity is .700.

Q. What is the composition of æther?

A. It is a compound of one volume of olefiant gas with half a volume of aqueous vapour; or, in ultimate elements of five equivalents of hydrogen, four equivalents of carbon and one equivalent of oxygen. Its proximate equivalent constitution are four equivalents of olefiant gas and one equivalent of water.

Q. What is the constitution of the oil of wine?

A. It is supposed to be a compound of two proportions of sulphuric acid to eight proportions of olefiant gas.

Q. What is Hoffman's anodyne liquor?

A. It is alcohol, containing the oil of wine which comes over with æther.

Q. What is the constitution of sweet spirits of nitre?

A. It is nitric æther and alcohol, in variable proportions.

Substances in which the oxygen is in excess for forming water with the hydrogen.

Q. What are these?

A. The vegetable acids.

Q. Can you enumerate some of the important vegetable acids?

A. Oxalic, tartaric, acetic, gallic, citric, malic, meconic, kinic, benzoic, succinic, &c.

Q. Where does oxalic acid exist?

A. In several plants, as the common and wood sorrel, and in union with lime, &c.

Q. How is oxalic acid obtained?

A. By the action of nitric acid on sugar. Nitric acid is decomposed into oxygen and nitric oxide, while the sugar is converted, with formation of carbonic acid and water, into oxalic acid.

Q. What are the properties of oxalic acid?

A. It is a crystalline solid, of a sour taste, soluble in water and alcohol, and poisonous.

Q. What is the salt of sorrel?

A. Binoxalate of potash.

Q. What is the best test for oxalic acid?

A. Lime, forming an insoluble oxalate. Magnesia and the bicarbonated alkalies are antidotes to its poisonous effects.

Q. What is the composition of oxalic acid?

A. Its ultimate constitution are two equivalents of carbon to three equivalents of oxygen. Its proximate constituents are earbonic oxide and carbonic acid, each one equivalent, and water three equivalents.

Q. What is the effect of sulphuric acid on it?

A. In consequence of its affinity for the water, which holds the proximate elements together, it is decomposed into carbonic oxide and carbonic acid.

Q. Where does tartaric acid exist?

A. In many vegetable substances, and as a deposition from wine in the form of bitartrate of potash.

Q. How is it obtained?

A. By saturating the excess of tartaric acid in cream of tartar with chalk, and decomposing the precipitate with dilute sulphuric acid.

Q. What are the properties of tartaric acid?

A. It has a sour taste, soluble in water and alcohol, and distinguished from other acids by forming a white precipitate with the salts of potash. It possesses the singular property of uniting with two bases at once, forming what are called triple compounds. With oxide of antimony it forms tartar emetic, and with carbonate of soda Rochelle salt.

Q. What vegetable acid is most abundant in nature?

A. Acetic. It exists in the sap of almost all the plants, in many of the animal secretions, and is the product of the destructive distillation of vegetables. Vinegar is a dilute acetic acid.

Q. How is acetic acid obtained?

A. By distilling any of the acetates with sulphuric acid, and then redistilling.

Q. What conditions are required for acetous fermentation?

A. The presence of water, yeast and alcohol, in some, form at a temperature between 60 and 80 degress.

Q. What does the process consist in?

A. The conversion of alcohol into acetic acid. The rationale given is explained by the formation of carbonic acid and water, in consequence of the union of the oxygen of the air with the carbon and hydrogen of the alcohol, which escape, leaving hydrogen, carbon and oxygen in proper proportions for forming acetic acid.

Q. What are the properties of acetic acid?

A. It is a very sour, pungent liquid, very volatile, and volatilizes without entire decomposition, crystallizes at low temperatures, and its vapour burns with a white flame.

Q. Can you give the composition of acetic acid?

A. Its ultimate constitution are four equivalents of carbon and hydrogen with oxygen, each three equivalents.

Q. Where does gallic acid exist?

A. In the bark of trees and in nut galls united with tannin.

Q. What is citric acid?

A. It is a crystalline substance, existing in limes and lemons.

Q. Where is malic acid found to exist?

A. It is predominant in the apple.

Q. In what does meconic acid exist?

A. In opium, united with an alkaline substance called morphia.

Q. Give the distinguishing properties of meconic acid?

A. It is a crystalline solid, soluble in water and alcohol, producing an intense red coloured precipitate, with peroxide of iron, and an insoluble meconate of lead, with protoxide of lead.

Q. Where is kinic acid?

A. It exists in Peruvian bark, in union with quina and cinchona.

Q. What is benzoic acid?

A. It is a concrete volatile oil existing in gum benzoin.

Q. Where is succinic acid?

A. In amber it exists ready formed.

Q. What is pyroligneous acid?

A. It consists of acetic acid and empyreumatic oil, obtained by the destructive distillation of wood.

Q. Does prussic acid exist in vegetable substances?

A. Yes; found in laurel leaves, peach leaves and blossoms, &c.

Q. Is phosphorous acid found in vegetables?

A. It is found in the coverings of many seeds.

Substances which contain Nitrogen as a class.

Q. Enumerate vegetable substances that contain nitrogen?

A. Gluten, caoutchouc and the vegetable alkalies.

Q. Enumerate some of the vegetable alkalies?

A. Morphia, quinia and cinchonia are the most important.

Q. What properties are common to the vegetable alkalies?

A. They are all solid, white, inodorous, and of a bitter or acrid taste; they render the syrup of violets green, are all soluble in alcohol, and nearly or quite insoluble in cold water. Their neutral salts are more soluble in water, and the solution is precipitated by infusion of galls.

Q. How are these alkalies in general obtained?

A. They are separated from the acids with which they are combined as they exist in nature, by precipitation from a solution containing them with a more powerful salifiable base, such as potash, ammonia and boiling the solution with lime or magnesia and filtering. Purified by mixing with animal charcoal, and dissolving in boiling alcohol.

Q. What are the ultimate constituents of vegetable alkalies?

A. Oxygen, hydrogen, carbon and nitrogen. They yield ammonia by destructive distillation.

Q. Where is morphia found?

A. It is one of the active principles in opium, existing in union with meconic acid, as meconate of morphia.

Q. How is morphia obtained?

A. By precipitation of laudanum with ammonia.

Q. What properties distinguish morphia?

A. It is of a bitter taste, crystals in four-sided prisms, produces a fine red colour with nitric acid, and a solution thus reddened is precipitated, of a dull brown colour, by protomuriate of tin. Morphia may also be distinguished by decomposing iodic acid.

Q. Where does quinia exist?

A. In Peruvian bark, in union with kinic acid, as a kinate of quinia and cinchonia.

A. By boiling bruised bark in water, with a little sulphuric acid. Repeat the boiling again, until all the soluble matter is extracted, then saturate the acid with hydrate of lime, boil in alcohol, and afterwards distil off the latter.

Q. Give the distinguishing properties of quinia?

A. Its taste is bitter, difficult to crystallize, but when in crystals they are shaped like needles, and its sulphate is less soluble than the sulphate of cinchonia.

Q. What are the peculiar properties of cinchonia?

A. It is distinguished from quinia in its acetate, being uncrystallizable; it is very bitter, white, crystallizable, and soluble in boiling water.

Q. What is strychnia?

A. It is a poisonous principle, existing in nux vomica.

ANIMAL CHEMISTRY.

Q. What is the effect of ignition on animal matter?

A. It yields ammonia, carbonic acid, empyreumatic oil and water, thus proving the ultimate constitution of animal matter to be oxygen, hydrogen, carbon and nitrogen. Fatty matter contains no nitrogen.

Q. What are remote, organic, animal elements that are neither oily, acid nor resinous?

A. Fibrin, albumen and gelatin.

Q. In what does fibrin exist?

A. It forms the principle of muscle, and exists in chyle and blood.

Q. What are the properties of fibrin?

A. It is solid, white, insipid, inodorous, insoluble in cold water, and slightly soluble in boiling water; by the action of dilute nitric acid, it yields ammonia and is soluble in concentrated sulphuric acid.

Q. What is the composition of fibrin?

A. Carbon 18 atoms, hydrogen 14 atoms, oxygen 15 atoms, and nitrogen 3 atoms.

Q. Where is albumen found?

A. In the serum of the blood; it is an ingredient in chyle, and constitutes the white of eggs.

Q. What are the properties of albumen?

A. Liquid albumen is coagulated by heat, alcohol and acids. Solid albumen is insoluble in water, but soluble in alkalies, from which it is precipitated by acids. Muriate of tin, acetate

of lead, muriate of gold and tannin, all precipitate albumen. It is the best test and antidote for corrosive sublimate.

Q. What is the composition of albumen?

A. Carbon 15 atoms, hydrogen 13 atoms, oxygen 6 atoms, and nitrogen 3 atoms.

Q. Where is gelatin found?

A. It forms a part of the skins, and half the weight of the bones.

Q. What are the properties of gelatin?

A. It is solid, tasteless, colourless, soluble in boiling water, but more soluble in acetic acid; it is not acted upon by alcohol, æther, or the oils; partly precipitated by alcohol, and totally by tannin, the former taking away water; the latter, by forming an insoluble substance with it analogous to leather.

Q. What is the composition of gelatin?

A. It differs from albumen only in containing 4 or 5 per cent. more carbon, and 3 or 4 per cent. less oxygen.

Q. Why is the putrefactive fermentation of animal more offensive than that of vegetable substances?

A. Because of the presence of phosphorus and sulphur.

Q. Will fermentation go on in substances perfectly dry?

A. No. The presence of water is indispensable to the spontaneous decomposition of organic substances.

Q. Why does high temperature, as well as frost, arrest it?

A. In the one case the water is vapourized, in the other congealed.

Q. What are the products of putrefaction?

A. Water, ammonia, carbonic and acetic acid, carburetted and sulphuretted hydrogen, and sometimes phosphuretted hydrogen.

TABLE FOR TESTING.

Metallic Bodies.	Precipitants.	Precipitates.	Colour of Precipitates.
Potash,	muriate of platina,	chloro-palatinate of potash,	yellow.
	tartaric acid,	bitartrate of potash,	white.
Soda,			
Lime,	oxalate of ammonia,	oxalate of lime,	"
Magnesia,	pure alkalies,	hydrate of magnesia,	"
	carbonate of potash or soda,	carbonate of magnesia,	"
Baryta,	sulphuric acid,	sulphate of baryta,	"
Strontia,	alkaline carbonates,	carbonate of strontia,	"
Alumina,	alkal. carbonates & ammon.	hydrate of alumina,	"
Iron,	infusion of galls,	tanno-gallate of iron,	ink colour.
	cyanoferrite of potash,	prussian blue,	intense blue.
	meconic acid,	meconate of iron,	red.
Zinc,	pure potash or ammonia,	hydrate of the oxide of zinc,	white.
	fixed alkaline carbonates,	carbonate of zinc,	"
	sulphydrate of ammonia,	sulphydrate of the oxide zinc,	"
Lead,	sulphydric acid,	sulphide of lead,	black.
	chromate of potash,	chromate of lead,	orange yellow.
	idohydrate of potash,	iodide of lead,	gamboge yellow.
	metallic zinc,	arbor saturni.	lead colour.
Tin,	sulphydric acid,	sulphide of tin,	yellow.
	fixed alkaline carbonates,	carbonate of tin,	white.

TABLE FOR TESTING.—*Continued.*

Metallic Bodies.	Precipitants.	Precipitates.	Colour of Precipitates.
Cadmium,	sulphydric acid,	sulphide of cadmium,	yellow.
Copper,	iron or zinc,	metallic copper,	blue.
	ammonia,	ammoniated copper,	rich reddish.
	cyanoferrite of potash,	cyanoferrite of copper,	brown.
Bismuth,	water,	subnitrate of bismuth,	white.
Mercury,	sulphydric acid,	sulphide of mercury,	black.
corrosive sublimate,	albumen,	calomel,	white.
	lime water,	peroxide of mercury,	lemon yellow.
	caustic posash,	" "	yellow.
	carbonate of potash,	carbonate of mercury,	a brick red.
	ammonia,	the white precipitate,	white.
	cyanoferrite of potash,	cyanoferrite of mercury,	white, then yellow.
	idohydrate of potash,	deuto-iodide of mercury,	pale scarlet.
	proto-muriate of tin,	metallic mercury,	white, then gray.
	nitrate of silver,	chloride of silver,	white.
calomel,	caustic alkalies,	deoxidizes calomel,	black.
Silver,	chlorine or muriates,	chloride of silver,	white.
	phosphates,	phosphate ot silver,	yellow.
	idohydrate of potash,	iodide of silver,	greenish yellow.
	copper,	metallic silver,	silver colour.

TABLE FOR TESTING.—*Concluded.*

Metallic Bodies.	Precipitants.	Precipitates.	Colour of Precipitates.
Gold,	proto-muriate of tin,	purple of Cassius, which is a compound of peroxide of tin and oxide of gold,	purple.
Platinum,	muriate of ammonia,	muriate of platin. and ammon.,	yellow.
	muriate of tin,	metallic platinum,	scarlet.
Cobalt,	alkaline carbonates,	carbonate of cobalt,	pale pink.
Nickel,	pure and carbonated alkalies,	the hydrate of the protoxide and carbonate of nickel,	pale green.
Antimony,	pure and carbonated alkalies,	protoxide of antimony,	dirty white.
tartar emetic,	sulphydric acid,	kermes mineral,	orange yellow.
Arsenic,	sulphydric acid,	sulphide of arsenic,	yellow.
arsenic acid,	ammoniacal nitrate of silver,	arseniate of silver,	brick red.
arsenious acid,	ammoniacal nitrate of silver,	arsenite of silver,	yellow.
	" nitrate of copper,	arsenite of copper,	apple green.
	lime water,	arsenite of lime.	white.
Chromium,	lead,	chromate of lead,	orange yellow.
chromic acid,	protoxide of mercury,	chromate of mercury,	orange red.
	silver,	chromate of silver,	deep red, or purple.
Manganese,	cyanoferrite of potash,	cyanoferrite of manganese,	white, becomes brown.

A Table of the Discovery of the Metals with their equivalent number and specific gravities.

Metals.	Equiv weight.	Specific Gravities.	Dates of discovery.	Discoverers.
Potassium,	40	0.865	1807	Davy.
Sodium,	24	0.972	1808	Davy.
Lithium,	14		1818	Arfwedson.
Calcium,	20		1808	Davy.
Magnesium,	12		1808	Davy.
Barium,	70	4.	1808	Berzelius and Bontin.
Strontian,	44		1808	Davy.
Aluminum,			1805	Wohler.
Glucinum,	18		1828	Berzelius and Davy.
Zirconium,	22		1824	Davy.
Yttrium,	34		1808	Davy.
Thorium,			1829	Berzelius.
Iron,	28	7.61		
Zinc,	34	6.861		
Lead,	104	11,352		
Tin,	58	7.0		
Cadmium,	56	8.604	1817	Stromeyer.
Copper,	64	8.895		
Bismuth,	72	9.822	18cent.	
Mercury,	200	13.6		
Silver,	100	10.5		
Gold,	200	19.3		
Platinum,	96	21.45	1754	Lewis.
Palladium,	53	11.55	1803	Wollaston.
Rhodium,	44	10.649	1804	Wollaston.
Iridium,	96	15.86	1803	Tennant & Descotils.
Osmium,	96	7.	1804	Tennant.
Nickel,	26	8.237	1751	Cronstedt.
Cobalt,	26	7.844	1733	Brandt.
Cerium,	50		1806-7	Hisinger & Berzelius.
Antimony,	44	6.812	1600 ?	Basil Valentine.
Arsenic,	38	8.31	1733	Brandt.
Chromium,	32	5.	1797	Vauquelin.
Manganesium	28		1774	Galen, (supposed.)
Uranium,	208		1789	Klaproth.
Titanium,	32	5.3	1822	Klaproth & Gregor.
Molybdenum,	48	8.6	1782	Bergman & Hielm.
Tungsten,	96	17.4		M. M. Delthuyart.
Columbium,	185	5.6	1801	Hatchett.